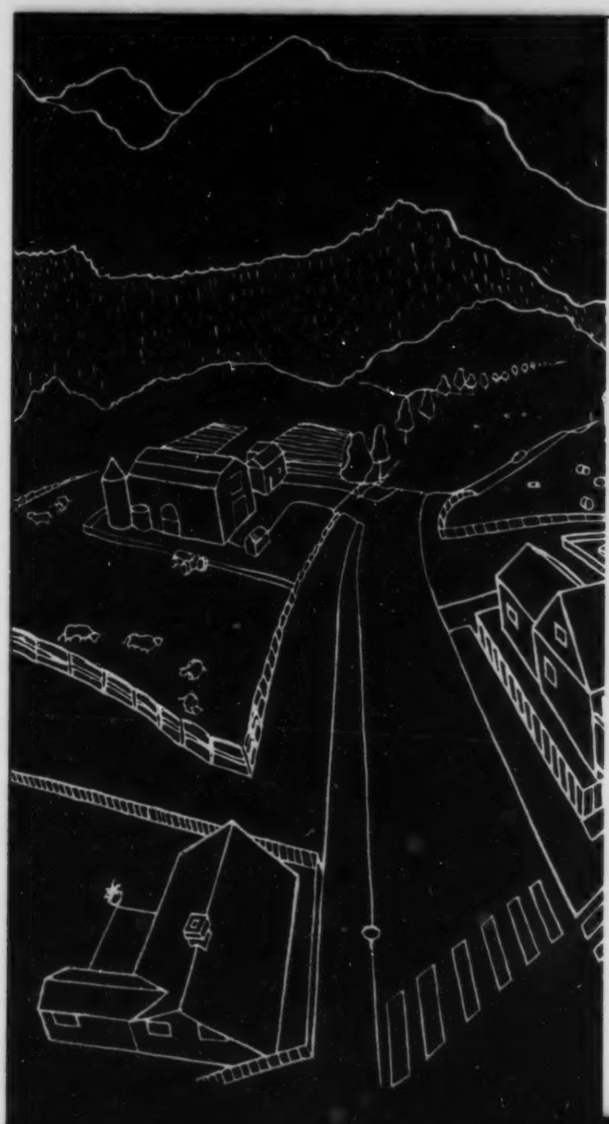

WELL PROTECTION TOOLKIT

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Over 750,000 British Columbians depend on groundwater for their drinking water supply. British Columbia accounts for nearly one-quarter (23%) of the total groundwater consumption across Canada, almost as much as the three prairie provinces combined or that of Ontario (27%). The demand for potable groundwater in this province is increasing as a result of population growth, increased industrial and commercial demands, and to some degree in response to the occurrence of waterborne diseases caused by micro-organisms, such as cryptosporidium and giardia, in surface water supplies.

Although the quality of groundwater in B.C. is generally excellent, there are local areas where water quality degradation is occurring. A significant percentage of the groundwater aquifers in B.C. are shallow and highly vulnerable to contamination. Experience from elsewhere in Canada, the U.S. and Europe shows that preventing water quality degradation by implementing a well protection plan is the best way to protect a community's well water supply. A well protection plan contains realistic protective measures to manage activities in the capture zone (or recharge area) to reduce the risk of contaminating the well supply.

Well protection planning has many advantages – it provides a mechanism for protecting drinking water sources, human health and the economic investment the water purveyor and community have made in the groundwater supply. While it is recognized that funding, technical expertise, and groundwater protection education are not always available to the degree that is desired, this situation should not keep a water purveyor from working in partnership with the community, its residents, businesses and local government to develop and implement an effective plan.

To assist water purveyors and communities in developing well protection plans, a *Well Protection Toolkit* has been prepared by the B. C. Ministry of Environment, Lands and Parks and Ministry of Health. The *Well Protection Toolkit* is a guide on how to develop and implement a well protection plan. The concepts contained in this *Toolkit* can also be used to protect the entire aquifer, in addition to the well capture zone(s).

The idea for a *Well Protection Toolkit* originated in 1995. In that year, the Provincial Government conducted the Fraser Valley Groundwater Monitoring Program study, which recommended that well protection plans be developed and implemented by well water purveyors in the Lower Fraser Valley. In 1996, the B.C. Ministry of Environment, Lands and Parks and Ministry of Health produced a fact sheet outlining a six-step approach to well protection planning. The six steps, as noted below, form the basis of the *Well Protection Toolkit*.

1. Form a community planning team;
2. Define the capture zone (recharge area) of the community well;
3. Map potential sources of pollution in the capture zone;
4. Develop and implement protection measures to prevent pollution;
5. Develop a contingency plan against any accidents; and
6. Monitor, evaluate, and report on the plan annually.

The *Toolkit*, which contains seven booklets, discusses these six steps in detail and includes an example of how each step is implemented in the fictitious community of Pumphandle, B. C.. The Pumphandle Community Planning Team succeeds in completing its first well protection plan, which is also included with the *Toolkit*.

At first glance, the *Well Protection Toolkit* can appear imposing. The *Toolkit*, however, is written for a broad audience with a varied background; for people with little or no technical knowledge, to individuals with specialized training in hydrogeology. As its name implies, the *Toolkit* is a tool to guide the reader through a process of ground water protection.

We sincerely hope this *Toolkit* will be useful to communities in B.C. and elsewhere in developing and implementing well protection plans to protect this valuable but hidden resource – our groundwater! Any feedback on the *Toolkit* and its usefulness will be appreciated. You will undoubtedly gain new knowledge and experience about well protection planning during your process, which in turn will be helpful to others. Pass your experiences on!

100-05418/

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AMBIENT GROUNDWATER FLOW: The rate of flow and direction of flow of groundwater under unpumped, natural conditions.

AQUIFER: A geological formation, group of formations, or part of a formation that consists of sufficient saturated permeable materials to yield economical quantities of water to wells and springs.

AQUIFER VULNERABILITY: An intrinsic measure of how easily an aquifer can be contaminated from activities at the land surface, based on the aquifer's geologic and hydrologic characteristics only. Vulnerability for an aquifer does not include the type and intensity of the human activities at the land surface.

AQUITARD: An aquitard is a geological formation that does not transmit a significant amount of water to wells and springs. An aquitard can, however, contribute a significant amount of water over a large area to an aquifer. Aquitards typically consist of till, silt or clay.

BACTERIA: One-celled microorganisms, some of which cause diseases in plants or animals.

BASE FLOW: The part of the streamflow that is derived from inflow of groundwater to the stream. Flows in a stream during the dry season is usually made up entirely of base flow.

BEDROCK: A general term for the solid rock that underlies soil or other unconsolidated materials.

CADASTRAL MAPS: Maps showing the legal property boundaries. Usually large scale maps.

CAPTURE ZONE: The land area around a pumping well which contributes water to the well. Also known as the recharge area for the well.

COMMUNITY WELL: A well supplying water to two or more dwellings or supplying any commercial premise serving the public.

CONCENTRATION: The amount of a chemical constituent in a given weight or volume of water, e.g. milligram per litre (mg/L).

CONFINED AQUIFER: Where an aquitard overlies an aquifer, the low permeability of aquitard can help in protecting the underlying aquifer from impacts of human activities at the land surface. In those cases, an aquifer is said to be "confined."

CONSTANT HEAD BOUNDARY: A hydraulic boundary of an aquifer where the water level is essentially stable and does not change. For example, a river or lake are often considered constant head boundaries for shallow aquifers.

CONTAMINANT INVENTORY: An office and field survey that identifies and locates potential sources of contamination in a specified area such as a capture zone area. Potential sources of contamination can be septic tanks, vegetable fields, contaminated industrial sites, etc.

CONTINGENCY PLANNING: The process of developing advance arrangements and procedures which enable the water purveyor to respond to an event that could happen by chance or unforseen circumstances.

DATABASE: A collection of records and files that are logically organized to assist with the analysis and processing of data.

DISCHARGE AREA: The land area where groundwater flows back towards the land surface. Features that are common to discharge areas are springs, wetlands and shallow water tables.

DRAWDOWN: The difference between the static water level and the pumping water level. Drawdown is expressed in metres (m) or feet (ft).

DRAWDOWN CONE: The difference between the pumping water level and the static water level decreases exponentially with distance in all directions away from a pumping well. The pumping water level forms a cone shape around the pumping well.

DRILLED WELL: A well that is constructed with a drilling rig, such as an air rotary or cabletool drilling rig.

DUG WELL: A well that is dug by hand or excavated by backhoe. Dug wells are usually shallow.

EMERGENCY RESPONSE PLAN: A set of standard operating procedures that addresses a number of emergency situations that are specific to the waterworks systems.

FLOWING ARTESIAN WELL: A well where the water level is above the ground surface.

FRACTURE: A break or crack in the bedrock.

GIS: Geographic Information System, a computer software and database that stores and analyzes geographic data. ArcInfo™ is an example of a GIS system.

GEOMORPHOLOGY: The study of landforms. Important in identifying aquifers and the occurrence of groundwater.

GLACIOFLUVIAL SEDIMENTS: Sand, gravel, silt and clay deposited by glacial rivers or streams.

GROUNDWATER: Water occurring beneath the ground.

GROUNDWATER DIVIDE: The uppermost groundwater boundary of a groundwater basin.

HOMOGENEOUS: Uniform in structure and composition throughout. For example, a homogeneous aquifer is an aquifer where the hydraulic conductivity of the sediments is uniform.

HYDRAULIC CONDUCTIVITY: A measure of the ease of flow of water through the aquifer. Hydraulic conductivity is usually expressed in metres per day (m/d) or feet per day (ft/d).

HYDRAULIC GRADIENT: The slope of the groundwater level or water table (for an unconfined aquifer), or the slope of hydraulic head level (for a confined aquifer). Hydraulic gradient is usually expressed as a unitless value.

HYDRAULIC HEAD: The level to which water rises in a well with reference to a datum such as sea level. Hydraulic head is usually expressed in metres (m) or feet (ft) above sea level.

HYDROGEOLOGIC MAPPING: Mapping groundwater and groundwater related features. A contour map of the water table, a map outlining the aquifer boundary and thickness, or a map showing the rate and direction of groundwater flow in an aquifer are examples of hydrogeologic maps.

HYDROGEOLOGY: The study of the flow of water and chemicals through the geological formations.

HYDROGRAPH: A continuous graph showing the rate of streamflow or level of groundwater over time.

HYDROLOGIC CYCLE: The continual circulation of water between the ocean, atmosphere, and land.

INFILTRATION RATE: The rate at which water permeates the pores or interstices of the ground.

ISOTROPIC: Exhibiting properties with the same values in all directions. For example, the hydraulic conductivity in a sand and gravel aquifer may be assumed to be equal in all directions, and the aquifer is said to be isotropic.

KARST AQUIFER: Limestone aquifer where groundwater flows through openings formed by water dissolving the rock fractures; these openings are commonly much larger than fracture openings (e.g. caverns, cavities).

LEACHING: Refers to the dissolution of chemicals into the water and movement of chemicals through soil by water.

LEVEL OF GROUNDWATER DEVELOPMENT: The level of groundwater use of an aquifer relative to the aquifer's ability to replenish itself.

LITHOLOGY: All the physical properties, the visible characteristics of mineral composition, structure, grain size, etc. which characterize a rock or sediment. For example, "coarse-grained sand" is a lithological description.

MAXIMUM ACCEPTABLE CONCENTRATION: The concentration established for certain substances that are known or suspected to cause adverse effects on health. These concentrations are derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration.

MEAN: The arithmetic mean or average of a set of numbers is calculated by totalling the items in the set and dividing the total by the number of items in the set.

MEDIAN: The value from a set of measurements that has an equal number of measurements above and below it.

METHOD DETECTION CONCENTRATION (MDC): The lowest amount of a constituent that can be reliably detected/measured based on the variability of either the blank response of a method or that of a low-level standard.

MONITORING WELLS: Wells that are typically 5 cm to 15 cm (2 inches to 6 inches) in diameter and are used strictly for monitoring the water quality of the aquifer. Monitoring wells are not pumped except to collect a sample.

NON-POINT SOURCE CONTAMINATION: Contamination where the source is diffuse (e.g. urban runoff).

NUMERICAL MODEL: A computer model that is designed to solve a set of mathematical equations that describe the physics of the system that one is modelling (such as an aquifer). Numerical models are usually developed to predict the water table elevation, flow rates, and/or chemical concentrations of a particular contaminant in different parts of the aquifer and over time and is a useful tool to assess implications of different policies or actions being contemplated for an aquifer area.

OBSERVATION WELL: A well used for the purpose of observing parameters such as water levels, pressure changes and water quality in aquifers.

OVERBURDEN: The loose soil, silt, sand, gravel, or other unconsolidated materials overlying bedrock, either transported or formed in place.

PERMEABILITY: The capacity of a porous rock, sediment, or soil for transmitting a fluid; it is a measure of the relative ease of fluid flow. Permeability is usually expressed in metres squared (m^2) or feet squared (ft^2). It is closely related to the hydraulic conductivity.

PESTICIDE: Under the B.C. *Pesticide Control Act*, any substance or mixture of substances, other than a device, intended for killing, controlling or managing insects, rodents, fungi, weeds and other forms of plant or animal life that are considered to be pests.

pH: A numerical measure of the acidity of water ranging from 0 to 14. Neutral waters have pH near 7. Acidic waters have pH less than 7 and basic (alkaline) waters have pH greater than 7.

POINT SOURCE CONTAMINATION: Contamination where the source is site specific (e.g. landfill).

POROSITY: The percentage of the bulk volume of a rock or soil that is occupied by interstices, relative to the total rock or soil volume. Porosity is usually expressed as a fraction or percentage.

PUMPING INTERFERENCE: The condition occurring when a pumping well lowers the water level in a neighbouring well.

PUMPING TEST: A test that is conducted to determine aquifer or well characteristics. A pumping test is usually conducted to determine the transmissivity and storativity characterstics of an aquifer and the capacity of a well supply.

PURVEYOR: A company, individual or municipality that delivers and sells water to clients, usually the residents in the community.

QUALITY ASSURANCE: The overall verification program which provides producers and users of data the assurance that predefined standards of quality at predetermined levels of confidence are met.

QUALITY CONTROL: The overall system of guidelines, procedures and practices which are designed to regulate and control the quality of products or services with regards to previously established performance criteria and standards.

RECHARGE AREA: Land area where water infiltrates into the ground and replenishes the aquifer.

SALINE GROUNDWATERS: Groundwater consisting of or containing a significant amount of salt.

SANDPOINT: A well pipe with a screen, equipped with a hardened, conical point at the bottom, that is driven into the ground to tap shallow groundwater.

SANITARY SURFACE SEALS: A grouted annular space around the well casing which usually extends from the land surface to several metres deep. The sanitary well seal functions to prevent any contaminated surface and near surface water from seeping down the side of the well to the aquifer.

SEDIMENTARY ROCKS: Rocks formed from consolidation of loose sediments such as clay, silt, sand, and gravel (e.g. sandstone, shale).

SOLE SOURCE AQUIFER: The only source of groundwater supply in an area.

SPECIFIC CAPACITY: The rate of discharge of water from a pumping well per unit of drawdown, commonly expressed in litres per second per metre (L/m/s) of drawdown or gallons per minute per foot (gpm/ft) of drawdown. Specific capacity usually decreases with duration of pumping.

SPECIFIC CONDUCTIVITY: The measure of the ability of water to conduct an electrical current. Specific conductance reflects the concentration of dissolved solids in the water. A rapid determination of total dissolved solids (TDS) of a water sample can be made by measuring the specific conductance. Specific conductance is expressed as microSiemens per centimetre (μS/cm) and is usually 1.5 to 2 times the TDS.

SPILL CONTINGENCY: A plan developed to deal with unexpected spills of contaminants.

STATIC WATER LEVEL: The unpumped level of water in the well or in the aquifer, measured from the ground level.

STEADY-STATE FLOW: State of groundwater flow where rate and direction does not change with time.

STORATIVITY: Volume of water stored or released from a column of aquifer (with unit cross section under unit change in head).

SURFICIAL DEPOSITS: Deposits overlying bedrock and consisting of soil, silt, sand, gravel and other unconsolidated materials.

TILL: Predominantly unsorted and unstratified drift, generally unconsolidated, deposited directly by and underneath a glacier without subsequent reworking by meltwater, and consisting of a heterogenous mixture of clay, silt, sand, gravel and boulders ranging widely in size and shape.

TIME OF TRAVEL: The time it takes for a particular contaminant to be transported through groundwater flow to a specified location. Time of travel is commonly used to relate the distance of a contaminant source to a drinking water well (e.g. "that gas station is located within a one-year time of travel distance from the community well").

TOPOGRAPHY: The configuration of a surface including its relief and the position of its natural features.

TOTAL DISSOLVED SOLIDS; TDS: A term that expresses the quantity of dissolved minerals in water. TDS is expressed in milligrams per litre (mg/L) or parts per million (ppm).

TRANSMISSIVITY: The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity of an aquifer is the hydraulic conductivity of the aquifer multiplied by the aquifer thickness. Transmissivity is expressed as metres squared per second (m^2/s), feet squared per day (ft^2/d), or gallons per day per foot (gpd/ft).

UNCONFINED AQUIFER: An aquifer where its upper boundary is defined by the water table. Where no aquitards overlie the aquifer, the aquifer is said to be "unconfined." Unconfined aquifers are generally more vulnerable to impacts from human activities at the land surface, particularly if the water table is shallow.

UNCONSOLIDATED DEPOSITS: Deposits overlying bedrock and consisting of soil, silt, sand, gravel, clay and other material which have either been formed in place or have been transported in from elsewhere. Synonymous with Surficial Deposits.

UNIFORM FLOW: Groundwater flow in the same direction and rate.

VOLATILITY: The degree to which a solid or liquid evaporates (evolves a gas).

WATER TABLE: The top of the unconfined aquifer; water level where the pressure is equal to that of the atmosphere; water level in a shallow well.

WELL CAP: Cover for the top of the well.

WELL CAPACITY OR WELL YIELD: The flow of water discharged from a well in gallons per minute (gpm) or litres/second (L/s).

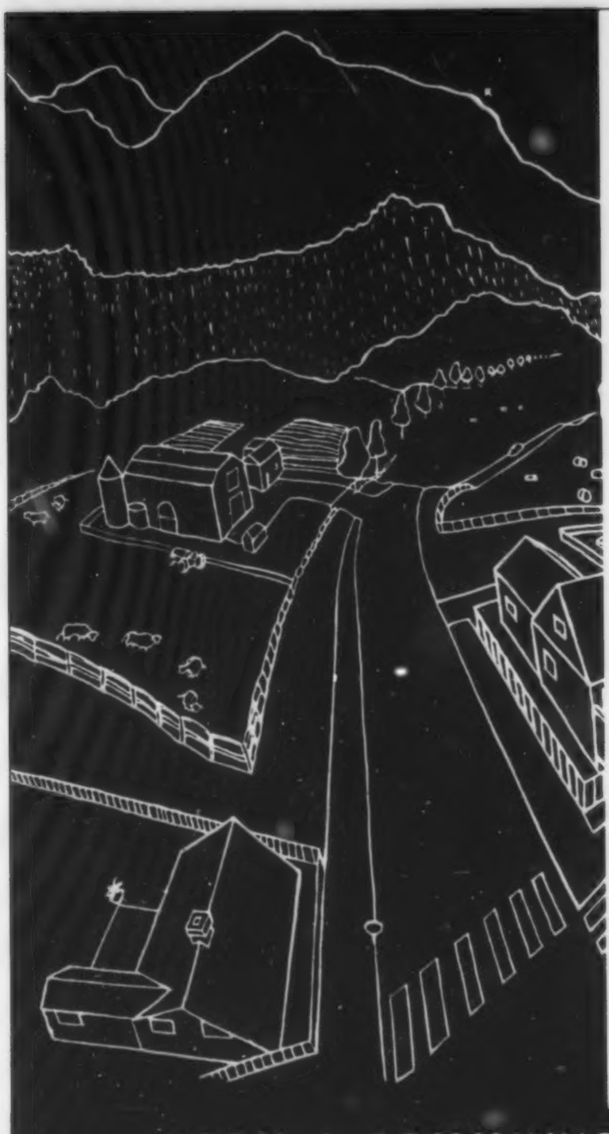
WELL SCREEN: A wire-wound filtering device that allows water but not sediments from entering the well.

WELL PROTECTION: Protection of the recharge (or capture zone) area of a pumping well. Synonymous with the term Wellhead Protection used in the United States.

WINDSHIELD SURVEY: A survey of the capture zone area done by driving through all parts of the area noting the potential sources of contamination. This type of survey works best in areas where most of the sources can be seen from the road.

ACRONYMS

AC	Agriculture Canada
AFR	arbitrary fixed radius
ALR	agricultural land reserve
b	aquifer thickness
B.C.	British Columbia
BCGWA	British Columbia Ground Water Association
BCWWA	B.C. Water and Waste Association
BMP	best management practice
CCME	Canadian Council of Ministers of the Environment
CDBMS	computerized database management system
CFR	calculated fixed radius
CPT	community planning team
d_{TOT}	distance representing the one-, five-, or ten-year time of travel
DFO	Department of Fisheries and Oceans
EC	Environment Canada
EHO	Environmental Health Officer
EMS	Environmental Monitoring System
GIS	geographic information system
i	hydraulic gradient
IPM	integrated pest management
K	hydraulic conductivity
MAC	Maximum Acceptable Concentration
MAF	Ministry of Agriculture and Food
MELP	Ministry of Environment, Lands and Parks
MEM	Ministry of Energy and Mines
MMA	Ministry of Municipal Affairs
MHO	Medical Health Officer
MOH	Ministry of Health
n	porosity
NMP	Nutrient Management Plan
NO_3-N	nitrate-nitrogen
NTS	National Topographic System
PEP	Provincial emergency program
PERC	perchloroethylene
PHE	Public Health Engineer
Q	pumping rate
QA/QC	quality assurance/quality control
r	radius
RCMP	Royal Canadian Mounted Police
S*M*A*R*T	specific, measurable, achievable, realistic and time-bound
t	time
T	aquifer transmissivity
TDS	total dissolved solids
TOT	time of travel
TRIM	Terrain Resource Information Management
U.S.	United States
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WELL	Provincial water well database
WSACS	Water Sampling Analysis Computer System
X	horizontal distance from the well to the down-gradient edge of a parabolic capture zone
Y	horizontal half width of a parabolic capture zone



Step One

FORM A COMMUNITY PLANNING TEAM

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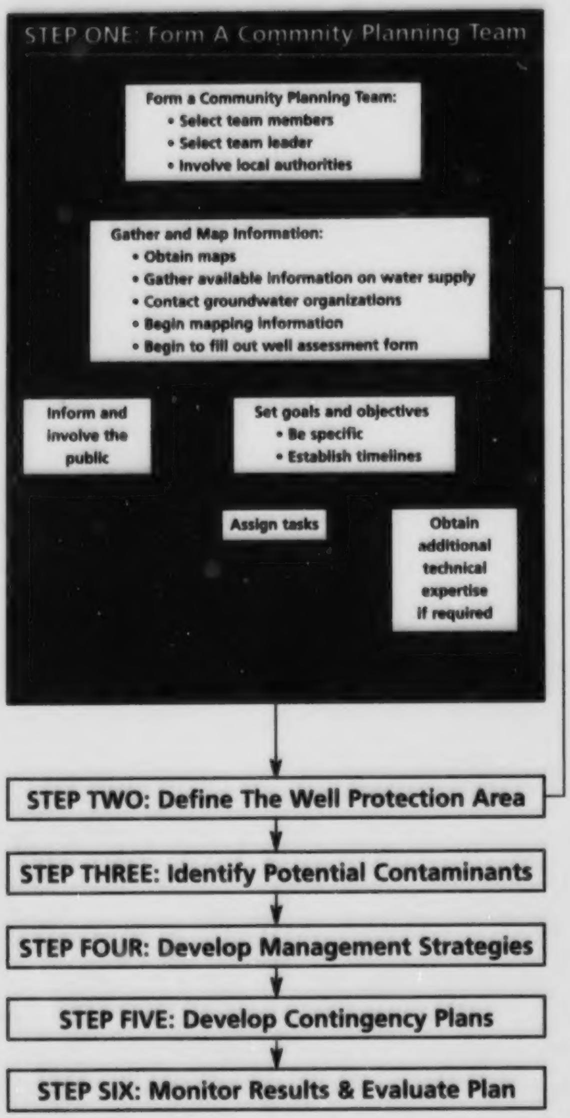
Figure 1.1


STEP ONE: Form A Commnity Planning Team
Form a Community Planning Team:
• Select team members
• Select team leader
• Involve local authorities
Gather and Map Information:
• Obtain maps
• Gather available information on water supply
• Contact groundwater organizations
• Begin mapping information
• Begin to fill out well assessment form
Inform and involve the public
Set goals and objectives
• Be specific
• Establish timelines
Assign tasks
Obtain additional technical expertise if required
STEP TWO: Define The Well Protection Area
STEP THREE: Identify Potential Contaminants
STEP FOUR: Develop Management Strategies
STEP FIVE: Develop Contingency Plans
STEP SIX: Monitor Results & Evaluate Plan

More than 750,000 British Columbians rely on groundwater as their source of drinking water, and there are thousands of community well systems in British Columbia. A well protection plan allows communities to identify land use activities that may threaten the quality of their well water, and to develop a strategy to avoid or minimize these threats.

There are six steps to follow in developing a well protection plan:

1. Form a community planning team
2. Define the well protection area
3. Identify potential contaminants
4. Develop and implement management strategies
5. Develop contingency plans
6. Monitor results and evaluate the plan

These steps are described in the six booklets that make up the *Well Protection Toolkit*. Each booklet describes activities that lead to the development and implementation of a well protection plan. In each step, a fictional case study of the town of Pumphandle shows how one community took on this challenge.

Step One: Form a Community Planning Team

The first step is to bring together a "community planning team" that will guide the development of the well protection plan – making sure that all the right groups and individuals are involved in the activities. The team must then become familiar with their groundwater supply and the community resources available to help, and set their protection goals. They will then assign tasks to the team members, including the job of making sure that the public is fully informed.

Figure 1.1 shows the stages of Step One.

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Form a Community Planning Team

OBJECTIVES

- To set up a planning team that includes water purveyors, community members and technical experts
- To coordinate efforts with other agencies
- To assess information needs and acquire information for the well protection process
- To develop goals and objectives for the well protection plan
- To develop an action plan and assign tasks

1.1 Select the Community Planning Team

The first step in developing a well protection plan is to bring together a group of people who have the interest and expertise to see the job through. This "community planning team" plays a major role in the ongoing success of well protection planning, as they are responsible for developing and implementing the plan. Involving people who are knowledgeable about the area, committed to the process and enthusiastic will help to ensure the plan's success.

Members of the community planning team should be prepared for a long-term commitment to this process. Some tasks and projects may take months or even years to complete, and would benefit from continuity in team membership. The water purveyor, or owner of the community well and waterworks system, is often in the best position to initiate the well protection planning process and to provide the long term commitment to see a well protection plan from its beginning steps through to implementation.

To succeed, the development of the well protection plan must involve a wide range of community interests. Citizens, business owners, and community groups all have an interest in protecting their source of drinking water, however some of these interests may conflict. It is important that the full range of interests be considered. The community planning team must work together to achieve a common set of goals and objectives.

VOLUNTEERS

In many situations, the community planning team will rely on the contribution of volunteers. Volunteers are not paid to participate on the team or in the development of the well protection plan. They are there because of an interest in protecting their source of drinking water. The volunteers on the team may be employed, requiring that team meetings be arranged in the evenings. The community planning team must consider their volunteers and their commitments when assigning tasks, setting time lines and scheduling meetings. Working together will get the job done!

Choose Representatives

The water purveyor is a key player in developing a well protection plan. He or she has the strongest interest in protecting the water supply, and may be in the best position to start the planning process. The water purveyor and the community can work side-by-side to meet the common goal of protecting the drinking water source.

How many people should be included? It depends on the size of your community, but six to eight members is a typical size (a larger group may slow the process). Include the people with an interest or a stake in the well protection area and those that can impact the aquifer and wells by their activities. You may choose to have a small core group, with additional members recruited for special projects.

Not everyone has to be a groundwater expert, but it is helpful to include some members with technical or planning expertise. Appendix 1.1 lists the types of people that might be invited, the experience they would bring and interests they represent.

Try to include a full range of community interests. Invite representatives from the business community and local environmental group. Are there special considerations for your area? An agricultural region,

Form a Community Planning Team

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- To develop an action plan and assign tasks

1.1 Select the Community Planning Team

The first step in developing a well protection plan is to bring together a group of people who have the interest and expertise to see the job through. This "community planning team" plays a major role in the ongoing success of well protection planning, as they are responsible for developing and implementing the plan. Involving people who are knowledgeable about the area, committed to the process and enthusiastic will help to ensure the plan's success.

Members of the community planning team should be prepared for a long-term commitment to this process. Some tasks and projects may take months or even years to complete, and would benefit from continuity in team membership. The water purveyor, or owner of the community well and waterworks system, is often in the best position to initiate the well protection planning process and to provide the long term commitment to see a well protection plan from its beginning steps through to implementation.

To succeed, the development of the well protection plan must involve a wide range of community interests. Citizens, business owners, and community groups all have an interest in protecting their source of drinking water, however some of these interests may conflict. It is important that the full range of interests be considered. The community planning team must work together to achieve a common set of goals and objectives.

VOLUNTEERS

In many situations, the community planning team will rely on the contribution of volunteers. Volunteers are not paid to participate on the team or in the development of the well protection plan. They are there because of an interest in protecting their source of drinking water. The volunteers on the team may be employed, requiring that team meetings be arranged in the evenings. The community planning team must consider their volunteers and their commitments when assigning tasks, setting time lines and scheduling meetings. Working together will get the job done!

Choose Representatives

The water purveyor is a key player in developing a well protection plan. He or she has the strongest interest in protecting the water supply, and may be in the best position to start the planning process. The water purveyor and the community can work side-by-side to meet the common goal of protecting the drinking water source.

How many people should be included? It depends on the size of your community, but six to eight members is a typical size (a larger group may slow the process). Include the people with an interest or a stake in the well protection area and those that can impact the aquifer and wells by their activities. You may choose to have a small core group, with additional members recruited for special projects.

Not everyone has to be a groundwater expert, but it is helpful to include some members with technical or planning expertise. Appendix 1.1 lists the types of people that might be invited, the experience they would bring and interests they represent.

Try to include a full range of community interests. Invite representatives from the business community and local environmental group. Are there special considerations for your area? An agricultural region, for example, should include a representative from the farming community.

Draw up a list of potential team members. Invite them to join the team. Be sure that they understand what will be required of them, and that they are prepared to commit to the whole process. Once the "well protection area" has been defined (Step Two), you may wish to review the team's membership to ensure that it represents the entire area.

Involve Local Authorities

The support of public officials is equally important. Include all agencies with control over the land-use practices that affect water quality, either as a member of the planning team or by keeping them regularly informed. Regional Health Authority staff (see Appendix 1.2) can provide valuable information and guidance on well protection planning, as well as technical support.

In larger communities, there is greater need for local government representation on the community planning team. Regulatory approaches may be needed to implement the well protection plan, requiring changes to by-laws or enforcement of regulations by the municipal or regional government.

Where there is an industrial base within the well protection area, business interests should be included. There is a potential for backlash from the business community should the well protection plan affect their operations, so be proactive and involve these interests from the outset.

Select a Team Leader

At your first meeting, select a team leader who will coordinate the team's activities, chair the meetings and keep the process going. The water purveyor, another local official who is familiar with the community and local regulations, a well-respected individual, or a community leader are all possible choices. Select someone who can lead the team towards success.

Once you have a team and leader, meet to agree on a process, set out some preliminary ideas on how you will get started and figure out what information you will need. Goal and objective setting comes later, however, you need to start somewhere!

WATERSHED LESSONS

The US Environmental Protection Agency offers some excellent examples of how well-managed groups can contribute to success in its document *Top 10 Watershed Lessons Learned* (publication EPA840-F-97-001). These "top ten" lessons apply equally to groundwater and well protection. You can read this document at:

www.epa.gov/owow/lessons

Keep Records

Developing a well protection plan will result in the collection and accumulation of records, maps, interviews, surveys, photographs and other documents. The team should secure a place to keep the records and find someone to be responsible for maintaining the records over the long term. It is possible for team members to come and go during the implementation and maintenance of the well protection plan, but not the records!

Form a Society

Consider forming a society - a legally identifiable entity (see sidebar). This can make it easier to apply for grants or loans to help fund the development and implementation of the well protection plan. Being a society will probably give you more "clout" when dealing with government, industry and individuals.

ON A LEGAL NOTE

The *Well Protection Toolkit* is written with the belief that the different interests in the well protection area can work together to meet the ultimate goal of protecting the groundwater. In some cases, the water purveyor or local government may be challenged on their authority to pass new by-laws, or approve other initiatives that could limit certain activities in the well protection area. The community planning team should consider under what circumstances they would need legal advice, and how they would go about getting that advice.

FORMING A SOCIETY

The Ministry of Finance and Corporate Relations is responsible for societies. A one-time fee is required to set up as a society. This cost includes the search and registration of the name of the society, and approval of the constitution and by-laws. A society must consist of at least five people, and must file for status on a yearly basis. You may want to ask a lawyer to review your draft constitution and by-laws to ensure they are complete and appropriate.

To form a society, call the Corporate and Personal Properties Registries at (250) 356-8673.[1] Once you reach the right department, request the Society Incorporation Package. This package will give the planning team everything that is required to form a society and will also provide you answers to most of your questions.

1.2 Gather and Map Background Information

After the planning team and a team leader have been selected, the work begins! It is important to gather some basic information before finalizing your goals and objectives, so that you know what you are dealing with. For example, the goals and objectives for wells located over a highly vulnerable aquifer will be different from those for wells located over a less vulnerable aquifer (see Step Two). You may have both types of aquifers in your well protection area.

Become Familiar with the Area

The first task is to obtain as much information as possible about your community well(s) and about the local groundwater resource. The planning team should become familiar with the hydrogeology,[2] the location of the well(s), the entire drinking water supply system and areas where development is planned. This knowledge will give you insight into the community's existing and future water supply needs and any water quality issues.

Groundwater organizations can provide educational materials and publications, informal networks and assistance on well protection planning (see sidebar). Call to find out how they can help. The Regional Health Authority (Appendix 1.2) may also be able to provide technical advice and assistance.

GROUNDWATER ORGANIZATIONS

Groundwater Guardian Program

Communities participating in the Groundwater Guardian Program have access to groundwater educational materials and publications, an informal network of organizations interested in groundwater protection, assistance with planning and expertise:

P.O. Box 22558
Lincoln NE USA 68542-2558
Website: www.groundwater.org
Phone: (800) 858-4844

B.C. Ground Water Association

The B.C. Ground Water Association is a non-profit organization dedicated to the development, conservation and protection of the B.C. groundwater resource. The Association comprises mostly water well drillers, pump contractors and suppliers, and professional hydrogeologists:

1708-197A Street
Langley, BC V2Z 1K2
Website: nanaimo.ark.com/~bcgwa
Phone: (604) 530-8934

Other Sources of Groundwater Information

Canadian Groundwater Issues: this site includes the *Canadian Groundwater Directory.*

Website: gwrp.cciw.ca/canada

Complete the Well Assessment Form

The well assessment form (Appendix 1.3) records basic information about the location of community wells, their construction and capacity, hydrogeology and capture zone,[3] as well as providing an assessment of water quality and likelihood of contamination. It is a good way to compile the available information.

It is unlikely that the team will have all the information to fully complete the well assessment for example, should include a representative from the farming community.

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It is unlikely that the team will have all the information to fully complete the well assessment form for each well at this early stage. However, starting to complete the form will help you to identify what information your group already has, and what is still missing. As other information is gathered during the plan development, it can be added to the well assessment form.

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[2] The geology of the area in relation to the movement of groundwater and contaminants.

[3] See Step Two, section 2.1.

It is also important to have information on the aquifer in which the well is constructed. If the aquifer consists of sand and gravel, contaminants will reach the well by travelling slowly through the pore spaces between the sand and gravel particles. If the aquifer consists of fractured bedrock, contaminants reaching the well will travel more quickly along the fractures. If the aquifer is covered by a sufficiently thick layer of clay or till, the aquifer is somewhat protected from contaminants on the surface, and they are less likely to reach the well. Without such as protective layer, the aquifer and well water are much more vulnerable to contamination from human activities.

It is important to know the type of aquifer in your area so you can develop your plan accordingly.

Map the Information

Maps provide a picture of your community groundwater supply and areas of risk, and help to convey this information to others.

Start with a base map of the community. This should include information on the natural features of the area and show the locations of all the community wells and other water supply sources. Think about what scale(s) of map will best show the entire area of interest, and can also show a sufficient level of detailed information. Do you need the map in digital format (for computer use) or will a paper map be adequate? Appendix 1.4 provides a summary of some of the maps most commonly used. If you are using more than one map, remember that it is easier if they are all the same scale.

Once a base map has been prepared, overlay maps can be drawn up to show a variety of information (see sidebar). Add what data you can now, and make a note of additional information that needs to be gathered at a later date.

Review the Information

Once you have assembled all the available information, your team can review it and determine what information is missing. You may identify the need for some immediate actions. For example, if there is a poor sanitary surface seal on a well, one of the first action items could be to replace the surface seal.

Information to be Included on Maps

Note that information will be added to the maps as the well protection plan develops.

STEP ONE:
- Aquifer(s)
- Location of wells
- Watersheds/boundaries

STEP TWO:
- Capture zone/well protection areas
- Fish bearing streams (in the event that main flushing will discharge chlorinated water)
- Location of any confining layers
- Wetlands
- Water table contours
- Vulnerable aquifer areas
- Flow directions

STEP THREE:
- Agricultural Land Reserve (ALR) lands
- Contaminated sites
- Official community plans
- High water-use industries and high risk sites
- Industrial areas
- Potential sources of contamination
- Sewer service areas and septic fields
- Zoning districts

STEP FIVE:
- Drainage infrastructure, such as ditches and sewers
- Waterworks system including the location of chlorinators, pumps, water lines (size, age, material), shut-off valves, pressure reducing valves, reservoirs, hydrants/standpipes, pressure zones
- Access routes, roads or trails to critical control points (e.g. shut-off valves)

STEP SIX:
- Location of water quality monitoring sites

ORGANIZING TO PROTECT

A community in the West Kootenays, with a population of 3,000 people, relies on community well water systems for its drinking water.

In the 1980s, one of the community wells was shut down because of contamination with gasoline from a leaky underground tank. In the early 1990s, the Ministry of Environment, Lands and Parks notified the local health unit and the four water districts that nitrate had been detected in the groundwater. These events raised concerns in the community about the safety of their water supply and in 1997, representatives from the four water districts, the city, the regional district and the local environmental health officer met to establish an Aquifer Protection Committee.

The committee drafted a mission statement and developed goals and objectives. They began collecting information on the aquifer and on land-use in the community and set up an Aquifer Resource Centre in the local public library. They then opened a bank account, applied for non-profit society status and established working groups that addressed public education needs, evaluated local bylaws that protect water quality, conducted a contaminant inventory survey, and looked into sources for possible funding.

In its first year, the committee spoke to many groups in the community about the need to protect their groundwater, had a booth at the Centennial Fair, and submitted articles to the local weekly paper about groundwater protection.

1.3 Set Goals and Objectives

Goals and objectives guide the development of the plan, and ensure that you focus on the most important activities.

Goals express the "desired state" of the project. Why do you need a well protection plan? Is it needed to protect the drinking water in the community? Is it needed to prevent further degradation of the groundwater supply? What do you want to achieve in the long term? Use these and other similar questions to set the goal(s).

Objectives set out how you are going to achieve your goals. They should be specific – how are they going to be achieved? Objectives should also be measurable – how can you tell if you have achieved what you set out to do? Some objectives are discarded once they are achieved; others may become an ongoing activity for the planning team.

A high-level, long-term goal, such as "developing and implementing a management plan to control high-risk activities within the capture zone," cannot be achieved overnight and should be broken down into a more manageable set of objectives, for example:

- To become familiar with the hydrogeology and groundwater conditions of the community well supply and with the location of the community's wells, the entire drinking water supply system and areas of future development;
- To gather all of the available information on the hydrogeologic nature of the aquifer(s); and
- To develop and maintain a groundwater monitoring program.

You may want to develop "indicators" to measure success. A measurable indicator could be the number of stakeholders and members of the public contacted and involved in the development of the well protection plan. Specific, achievable and measurable objectives will help you to evaluate the progress and success of the plan.

Obtain Funding

The community planning team will also need a financial plan. The financial plan can be developed as part of the overall strategy for developing a well protection plan. The community planning team must estimate the financial needs for developing and form for each well at this early stage. However, starting to complete the form will help you to identify what information your group already has, and what is still missing. As other information is gathered during the plan development, it can be added to the well assessment form.

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Don't wait to initiate a well protection plan until you feel you have sufficient funding. Start the plan now and tailor it to the funds that you have. The success of your modest protection plan may attract more funding from other sources. When larger amounts of funding becomes available in the future, your community will already have a plan and working process in place to take advantage of the funds. Remember, even a small amount of money can get you started! Developing relationships and trust within the community for the well protection planning process will take time; cultivate that relationship and trust now to get the community supporting groundwater protection, even though little funding may currently be available.

1.4 Assign Tasks

Once you know what you want to do, you will need to decide who will be doing the work, and when. An action plan outlining and assigning tasks and timeframes to individual team members will provide direction and help keep everyone focussed on the work to be done. For simpler tasks, the planning team can undertake all the work themselves. In larger and more complex situations, you may need the help of professionals.

The planning team should meet regularly, once or twice every month, to maintain momentum and keep everyone informed. These meetings are an opportunity to monitor the activities, and evaluate and assess progress of the work that has been completed.

Initial goals and objectives are often revised or expanded as the well protection plan develops, conditions change and the team becomes more familiar with the process. Team members should recognize and accept that the well protection plan will change over time. The well protection plan should be reviewed on a regular basis and changes should be made where necessary.

KEYS TO SUCCESSFUL PLANNING

- **Set clear goals**
- **Break down long-term objectives into smaller tasks that can be handled easily by individuals on your team – don't try to achieve too much too soon**
- **Set feasible short-term objectives while maintaining sight of your goals**
- **Establish plans and timetables**
- **Engage in exciting activities**
- **Have a strong will to succeed**
- **Recognize and celebrate successes**

1.5 Keep the Public Informed

It is important to inform the community at large of the progress in establishing a well protection plan. This helps educate people about the need to protect groundwater while generating support for the process itself. It also gives people an opportunity to be involved and to provide input. You are more likely to be successful if you have public support in monitoring and enforcing the well protection plan.

Mail-outs, advertisements, flyers, and community meetings are low-cost methods for reaching a broad spectrum of the community. Some methods are more effective than others. Responses to questionnaires given to the community can provide feedback and information related to the well protection plan, and can help the team determine what the groundwater issues are and where the sources of contamination may be. Informing the public of the groundwater activities can also be tied into other forums, such as service club meetings, existing newsletters, school assemblies and other community group meetings. Announcements in local newspapers, television and radio are also an effective means of getting the word out on the progress of the well protection plan.

You may choose to develop a communications or outreach plan, with the elements, budgets and responsibilities outlined. You could appoint a communications contact who speaks objectively on behalf of the team and issues. Consider a website; it could be useful for interactive consultation once public input is sought.

CHECKLIST FOR STEP ONE

The following is a basic checklist for action items to be completed during Step One of the well protection planning process:

ACTION ITEM	COMMENTS	COMPLETED
Identify potential members of the community planning team	Membership should be based on geographic as well as local government land areas and include a full range of community interests.	☐
Form a community planning team	Ensure commitment from all members.	☐
Select a team leader	The leader will chair meetings, facilitate dialogue and keep the process going.	☐
Get maps & background information	Establish a base map. Gather information on community wells and aquifers. Identify missing information.	☐
Start filling out well assessment form	Good starting point for information needs for the planning process.	☐
Develop goals and objectives	Objectives should be measurable and have an associated schedule. Set a workplan.	☐
Develop an action plan	Assign tasks to the community planning team to meet the goals.	☐
Involve and inform the public	Announce the well protection plan to the public and invite participation and support.	☐

implementing the plan, identify sources of funding and revise its estimates as the plan progresses and new information becomes available. The good news is that the money doesn't have to be raised and spent all at once. Funding sources can change – old ones disappear and new sources become available. Someone on the community planning team can be assigned to track sources of funding.

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Once you know what you want to do, you will need to decide who will be doing the work, and when. An action plan outlining and assigning tasks and timeframes to individual team members will provide direction and help keep everyone focussed on the work to be done. For simpler tasks, the planning team can undertake all the work themselves. In larger and more complex situations, you may need the help of professionals.

The planning team should meet regularly, once or twice every month, to maintain momentum and keep everyone informed. These meetings are an opportunity to monitor the activities, and evaluate and assess progress of the work that has been completed.

Initial goals and objectives are often revised or expanded as the well protection plan develops, conditions change and the team becomes more familiar with the process. Team members should recognize and accept that the well protection plan will change over time. The well protection plan should be reviewed on a regular basis and changes should be made where necessary.

KEYS TO SUCCESSFUL PLANNING

- Set clear goals
- Break down long-term objectives into smaller tasks that can be handled easily by individuals on your team – don't try to achieve too much too soon
- Set feasible short-term objectives while maintaining sight of your goals
- Establish plans and timetables
- Engage in exciting activities
- Have a strong will to succeed
- Recognize and celebrate successes

1.5 Keep the Public Informed

It is important to inform the community at large of the progress in establishing a well protection plan. This helps educate people about the need to protect groundwater while generating support for the process itself. It also gives people an opportunity to be involved and to provide input. You are more likely to be successful if you have public support in monitoring and enforcing the well protection plan.

Mail-outs, advertisements, flyers, and community meetings are low-cost methods for reaching a broad spectrum of the community. Some methods are more effective than others. Responses to questionnaires given to the community can provide feedback and information related to the well protection plan, and can help the team determine what the groundwater issues are and where the sources of contamination may be. Informing the public of the groundwater activities can also be tied into other forums, such as service club meetings, existing newsletters, school assemblies and other community group meetings. Announcements in local newspapers, television and radio are also an effective means of getting the word out on the progress of the well protection plan.

You may choose to develop a communications or outreach plan, with the elements, budgets and responsibilities outlined. You could appoint a communications contact who speaks objectively on behalf of the team and issues. Consider a website; it could be useful for interactive consultation once public input is sought.

CHECKLIST FOR STEP ONE

The following is a basic checklist for action items to be completed during Step One of the well protection planning process:

ACTION ITEM	COMMENTS	COMPLETED
Identify potential members of the community planning team	Membership should be based on geographic as well as local government land areas and include a full range of community interests.	☐
Form a community planning team	Ensure commitment from all members.	☐
Select a team leader	The leader will chair meetings, facilitate dialogue and keep the process going.	☐
Get maps & background information	Establish a base map. Gather information on community wells and aquifers. Identify missing information.	☐
Start filling out well assessment form	Good starting point for information needs for the planning process.	☐
Develop goals and objectives	Objectives should be measurable and have an associated schedule. Set a workplan.	☐
Develop an action plan	Assign tasks to the community planning team to meet the goals.	☐
Involve and inform the public	Announce the well protection plan to the public and invite participation and support.	☐

Appendix 1.1 Potential Members and Resources for the Community Planning Team

REPRESENTATIVE	ROLE/JURISDICTION
Purveyor of the community well	Delivering potable water to customers in the community, emergency response
LOCAL GOVERNMENT (municipalities and regional districts): Planners, Engineers Elected officials such as Mayors and councillors, Fire department personnel Personnel from water & wastewater treatment/landfill facilities Staff from Regional Health Authority (Public Health Engineers, Environmental Health Officers)	Zoning by-laws through official community plans, emergency response Septic system permits, ensuring safe drinking water supply, permits for water system construction and operation
PROVINCIAL GOVERNMENT STAFF FROM: Ministry of Environment, Lands and Parks	Regulation of surface water, handling, storage and disposal of manure, pesticide use, waste discharge, contaminated sites, water information, technical advice on groundwater; water utilities regulation
Ministry of Health	Septic system permits, ensuring safe drinking water supply, permits for water system construction and operation
Ministry of Agriculture and Food	Advising on Best Management Practices for agricultural activities
Ministry of Municipal Affairs	Funding for water system infrastructures, planning grants, legislative advice
Ministry of Transportation and Highways	Maintenance of roads and highways, approvals of subdivisions
Ministry of Energy and Mines	Permits and manages mining activities, issues tenures for metal and coal mining, and for oil and gas exploration and development
Ministry of Forests	Forest and range management
FEDERAL GOVERNMENT STAFF FROM: Environment Canada	Transboundary water issues, technical information on groundwater
Agriculture and Agri-Food Canada	Registration and approval of pesticide usage, research on Best Management Practices for agricultural activities
Health Canada and Department of Indian and Northern Affairs	Jurisdiction over native lands
REPRESENTATIVES FROM INDUSTRY AND ASSOCIATIONS: Land developers, Local Chambers of Commerce Industrial organizations (e.g. forest or gasoline companies) and their associations Well water drillers Environmental consultants, Communication media Association of Professional Engineers and Geoscientists of B.C. Consulting Engineers of B.C. (or their member groups) B.C. Federation of Agriculture (or local producer groups) B.C. Ground Water Association, B.C. Water and Waste Association Aggregate Producers Association	Individuals in your community who belong to these associations could be potential members of the community planning team
PUBLIC: Public interest groups Community service groups such as the Rotary Club Environmental/conservation groups Home owners or neighbourhood associations Interested individuals	Representation from the diverse interests of the community
EDUCATORS: Local school teachers, Scientific researchers University and college professors Representatives from the school district	Providers of expertise in education of the public and research on groundwater issues

Appendix 1.2 Listing of Regional Health Authorities and Ministry of Environment, Lands and Parks Contacts

REGIONAL HEALTH BOARDS AND HEALTH REGIONS	PHONE NUMBER[4]
North Okanagan Health Region	(250) 549-5700
Okanagan Similkameen Health Region	(250) 868-7814
Thompson Health Region	(250) 828-4411
Fraser Valley Health Region	(604) 795-8200
South Fraser Health Region	(604) 572-2600
Central Vancouver Island Health Region	(250) 755-6200
Northern Interior Regional Health Board	(250) 565-6099
Vancouver /Richmond Regional Health Board	(604) 736-2866
Vancouver /**Richmond** Regional Health Board	(604) 276-4047
North Shore Health Region	(604) 938-6700
Capital Health Region	(250) 370-8874
Simon Fraser/ Burnaby Health Region	(604) 525-3661
Simon Fraser/ **Burnaby** Health Region	(604) 294-7260

COMMUNITY HEALTH SERVICES SOCIETY	PHONE NUMBER
Coast Garibaldi Community Health Services Society	(604) 886-5600
Upper Island Central Coast Community Health Services Society	(250) 334-1172
North West Community Health Services Society	(250) 638-2220
Peace Liard Community Health Services Society	(250) 784-2400
Kootenay Boundary Community Health Services Society	(250) 365-4341
Cariboo Community Health Services Society	(250) 398-4600
East Kootenay Community Health Services Society	(250) 426-1455

MINISTRY OF ENVIRONMENT, LANDS AND PARKS OFFICES	PHONE NUMBER
Groundwater Section (Victoria)	(250) 387-1115
Cariboo (Williams Lake)	(250) 398-4530
Lower Mainland (Surrey)	(604) 582-5200
Peace Omineca (Prince George)	(250) 565-6135
Kootenay (Nelson)	(250) 354-6333
Skeena (Smithers)	(250) 847-7260
Vancouver Island (Nanaimo)	(250) 751-3100
Southern Interior (Kamloops)	(250) 371-6200

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[4] To save the costs of the phone call, go through your local Enquiry BC (the number is listed in the blue pages of the telephone directory) and they will connect you

Appendix 1.3 Well Assessment Form

BRITISH COLUMBIA
Ministry of Health and
Ministry Responsible for Seniors
Ministry of Environment,
Lands and Parks

WELL ASSESSMENT FORM

TO BE USED WITH THE WELL PROTECTION TOOLKIT.

IMPORTANT! Please complete one form for each ground water source used in your water system. Fill in available information. If missing information, it may be advisable to contact the Ministry of Environment, Lands and Parks' Groundwater Section [(250) 387-1115], or the local driller who drilled the well, to assist. Photocopy this form as necessary.

PART I: WELL SYSTEM INFORMATION (Refer to Step 1)

WATER SYSTEM LEGAL NAME
LEGAL DESCRIPTION OF WELL LOCATION

WATER SYSTEM LEGAL ADDRESS

LATITUDE / LONGITUDE
HOW WERE LOCATION COORDINATES DETERMINED?
☐ GPS ____________ *(specify accuracy)* ☐ survey ☐ digitized from ________________ map *(specify scale)*

UTM COORDINATES
HOW MANY OTHER WELLS MAKE UP THE WATER SYSTEM?
DOES THE WATER SYSTEM ALSO USE A SURFACE WATER SOURCE? *(describe)*

NUMBER OF CONNECTIONS
Maximum ________ Actual ________
POPULATION SERVED
WATER USE
☐ domestic ☐ irrigation ☐ commercial ☐ industrial other *(specify)* ________________

WIN NO.
EMS NO.
WELL TAG NO.

Contact your local Ministry of Environment, Lands and Parks office or local Health Unit for the following information:
WIN NO. = MoELP's metal tag affixed to the well for on-site identification.
EMS NO. = MoELP's site number for the water chemistry on their database.
BC WELL TAG NO. = MoELP's computer number for the well.

Bulk supply ☐ yes ☐ no
Back-up supply ☐ yes ☐ no
Emergency supply ☐ yes ☐ no
Metered ☐ yes ☐ no

WELL OWNER / OPERATOR INFORMATION

WELL OPERATOR
WELL OPERATOR'S PHONE NO. (   )

WELL OPERATOR'S ADDRESS

WELL OWNER
WELL OWNER'S PHONE NO. (   )

WELL OWNER'S ADDRESS

PART II: WELL CONSTRUCTION INFORMATION (Refer to Step 1)

WELL-DRILLER'S NAME, COMPANY AND ADDRESS
POSTAL CODE
WELL-DRILLER'S TELEPHONE NO. (   )
DATE WELL ORIGINALLY CONSTRUCTED YYYY MM DD
DATE OF LAST RECONSTRUCTION YYYY MM DD

TYPE OF WELL
☐ drilled ☐ dug ☐ other *(specify)* ____________
METHOD OF DRILLING
☐ rotary ☐ cable tool ☐ driven ☐ jetted ☐ other *(specify)* ____________
WELL LOG AVAILABLE?
☐ yes *(attach)* ☐ no

DEPTH OF WELL
________ m or ________ ft.
DIAMETER OF WELL
________ m or ________ in.
SCREEN LENGTH
________ m or ________ ft.
DEPTH TO TOP OF SCREEN
________ m or ________ ft.

WELL CAPACITY
________ L/s or ________ Igpm
LOCATION OF WATER-BEARING FRACTION(S) (for bedrock wells):
YIELD OF WATER-BEARING FRACTION(S)
________ L/s or ________ Igpm

WELLHEAD ENCLOSURE
☐ pump house ☐ manhole ☐ other *(specify)* ________ ☐ none
SURFACE SANITARY SEAL
grouted to ________ m or ________ ft. ☐ no surface seal ☐ pitless adapter

AVERAGE PUMPING RATE
________ L/s or ________ Igpm
HOW WAS PUMPING RATE DETERMINED?
DEPTH OF INTAKE SETTING
________ m or ________ ft.
PUMP AGE

ANNUAL VOLUME OF WATER PUMPED
________ L or ________ Igal
HOW WAS VOLUME PUMPED DETERMINED?

PUMPING CAPACITY
________ L/s or ________ Igpm
ANY CHANGES OR REPAIRS MADE TO THE PUMPING EQUIPMENT? *(specify)*

TYPE OF STORAGE
☐ tank(s) ☐ reservoir ☐ other *(specify)* ________________
STORAGE CAPACITY
________ L or ________ Igal
COMMON INLET OR OUTLET?
☐ yes ☐ no

ATTACHED INFORMATION
☐ well log ☐ drawings ☐ reports ☐ pump test data ☐ water quality data

NOTE: If no well log is available, please attach any other records documenting well construction (i.e., "as built" drawings, engineering reports).

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Appendix 1.3 Well Assessment Form (continued)

PART III: HYDROGEOLOGIC INFORMATION (Refer to Steps 1 and 2)

DEPTH TO PUMPING WATER LEVEL ______ m or ______ ft.	DEPTH TO NON-PUMPING WATER LEVEL ______ m or ______ ft.	HOW WAS WATER LEVEL MEASURED? ☐ well log ☐ wetted tape ☐ probe ☐ transducer

IF WELL IS FLOWING, WHAT IS THE ARTESIAN PRESSURE HEAD AND FLOW? ______ m or ______ ft.	HOW IS PRESSURE HEAD AND FLOW MEASURED? *(specify)*	IF SOURCE IS A FLOWING WELL OR SPRING, IS THERE A STORAGE IMPOUNDMENT OR RESERVOIR ASSOCIATED WITH THIS SOURCE? ☐ yes *(specify)* ______ ☐ no

WELLHEAD ELEVATION (height above mean sea level) ______ m or ______ ft.	HOW WAS ELEVATION DETERMINED? ☐ survey ☐ altimeter ☐ topographic ☐ map *(specify scale and contour interval)* ☐ other *(specify)* ______

TYPE OF CONFINING LAYER FROM WELL LOG (e.g., clay, till)	LOCATION OF CONFINING LAYER AT DEPTH FROM WELL LOG ____ m or ____ ft.	THICKNESS OF CONFINING LAYER FROM WELL LOG ____ m or ____ ft.	HOW LATERALLY EXTENSIVE IS CONFINING LAYER?

IS YOUR WELL ASSOCIATED WITH A KNOWN AQUIFER? ☐ yes ☐ no	NAME OF AQUIFER	AQUIFER CLASSIFICATION NUMBER (from MoELP)	AQUIFER CLASSIFICATION (from MoELP)

TYPE OF AQUIFER ☐ unconsolidated, unconfined ☐ unconsolidated, confined ☐ bedrock	ARE THERE OTHER HIGH-CAPACITY WELLS, 30 L/s OR 500 GAL./MIN. (agricultural, municipal and/or industrial), LOCATED WITHIN A 300-m RADIUS OF THE COMMUNITY WELL? ☐ yes How many? ______ ☐ no	ANNUAL RAINFALL ______ m or ______ in.

AQUIFER TRANSMISSIVITY ______ m^2/d or ______ Igpd/ft.	HOW WAS TRANSMISSIVITY DETERMINED? ☐ from pumping test ☐ from specific capacity ☐ other *(specify)* ______
HYDRAULIC GRADIENT	HOW WAS HYDRAULIC GRADIENT DETERMINED? ☐ from well water levels ☐ from topography ☐ other *(specify)*

PLEASE IDENTIFY OR DESCRIBE ADDITIONAL HYDROLOGIC OR GEOGRAPHIC CONDITIONS THAT YOU BELIEVE MAY AFFECT THE SHAPE OF THE CAPTURE ZONE FOR THIS SOURCE. WHERE POSSIBLE, REFERENCE THEM TO LOCATIONS ON THE MAP PRODUCED IN PART IV.

PART IV: ASSESSMENT OF WATER QUALITY (Refer to Step 1)

1 HOW LONG HAS THE WATER SYSTEM BEEN IN EXISTENCE?	**2** HAS YOUR WELL EVER BEEN DEEPENED, CLEANED, NEW WELL CONSTRUCTED? ☐ yes — Why? ______ ☐ no

3 IN THIS TIME, HAVE THERE BEEN ANY WATER QUALITY PROBLEMS? ☐ yes ☐ no ☐ don't know	IF YES, WHEN AND WHAT WAS THE CAUSE OF THESE PREVIOUS PROBLEMS (i.e., drought, pump failure, plugging, increased usage, interference, contamination)?

IF CONTAMINATION:
- WHAT WATER QUALITY CHANGES WERE APPARENT (i.e., taste, colour, turbidity, other)?
- WHAT ACTION WAS TAKEN TO OVERCOME THIS PROBLEM?
- WHAT WERE THE EFFECTS OF THIS ACTION?

4 **BACTERIAL CONTAMINATION**

ANY BACTERIAL DETECTION(S) IN THE PAST 3 YEARS BASED ON SOURCE-MONITORING RECORDS?	☐ yes ☐ no	HAVE THERE BEEN SAMPLING PROTOCOLS OR QA/QC ESTABLISHED? ☐ yes ☐ no
HAS SOURCE (IN PAST 3 YEARS) HAD A BACTERIOLOGICAL CONTAMINATION PROBLEM FOUND IN DISTRIBUTION SAMPLES THAT WAS ATTRIBUTED TO THE SOURCE?	☐ yes ☐ no	IF YES, WHAT ARE THEY?
WAS THE BACTERIOLOGICAL CONTAMINATION DUE TO THE SOURCE?	☐ yes ☐ no	
WAS THE BACTERIOLOGICAL CONTAMINATION DUE TO CROSS-CONNECTIONS?	☐ yes ☐ no	
IS THE WELL AVAILABLE FOR DIRECT SAMPLING?	☐ yes ☐ no	

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Appendix 1.3 Well Assessment Form (continued)

SOURCE-SPECIFIC WATER QUALITY RECORDS

Please indicate the occurrence of any test results in the last 10 years that meet the following conditions:

PARAMETER	RECURRING PROBLEMS	TEST RESULTS	EXCEEDENCES OF CDWQG[1]
Bacteriological Total/Faecal Coliforms Background Heterotrophic plate counts Iron and Sulphate Reducers			
Disinfection by-products Bromodichloromethane Dibromochloromethane Chloroform			
Physical Parameters pH, colour, alkalinity, specific conductance, hardness, total dissolved solids, total organic carbon, turbidity			
Inorganic Parameters Nitrates, fluoride, sulfate, sulphide, ammonia, chloride, nitrite, nitrogen (organic)			
Metals* Calcium, iron, magnesium, manganese, sodium			

[1] Canadian Drinking Water Quality Guidelines, 6th edition

* A metal scan is usually performed every 3 years at least, and includes aluminum, arsenic, barium, cadmium, chromium, copper, lead, molybdenum, nickel, phosphorus, silver and zinc.

Please sketch in the box below the location sampling point with respect to the well.

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Appendix 1.3 Well Assessment Form (continued)

PART V: WATER TREATMENT INFORMATION (Refer to Step 1)

IS THIS SOURCE TREATED? ☐ yes ☐ no

IF YES, TYPE OF TREATMENT ☐ disinfection ☐ filtration ☐ carbon filter ☐ air stripper ☐ water softener ☐ other *(specify)* ____________

PURPOSE OF TREATMENT

IF SOURCE IS CHLORINATED, IS A CHLORINE RESIDUAL MAINTAINED? Total Chlorine ________ ppm Free Chlorine ________ ppm

WHAT IS THE RESIDUAL LEVEL OF TREATMENT?

IS THERE ANY WATER STORAGE IN THE SYSTEM? ☐ yes ☐ no

IS THE WATER TREATMENT BEFORE OR AFTER THE STORAGE UNIT? ☐ before ☐ after

WHAT IS THE TOTAL AND FREE CHLORINE IN THE DISTRIBUTION SYSTEM? Total Chlorine ________ ppm Free Chlorine ________ ppm

IS THERE ANY ADDITIONAL CHLORINE ADDED AFTER THE SOURCE (rechlorination)? Total Chlorine ________ ppm Free Chlorine ________ ppm

WHAT TYPE OF CHEMICALS ARE USED IN THIS PROCESS? *(specify)*

WHERE ARE CHEMICALS STORED?

IS THERE PROPER STORAGE FOR THESE CHEMICALS? ☐ yes ☐ no

IF STORED IN PUMP HOUSE, HOW ARE CHEMICALS ISOLATED FROM THE WELL?

PART VI: MAPPING THE CAPTURE ZONE TO YOUR COMMUNITY WELL (Refer to Step 2)

A map (1:5000 to 1:20,000 are typical scales) will be needed to complete this section. Multiple wells in the same area can be plotted on one map.

CIRCULAR CAPTURE ZONE (refer to Appendix 2.1)

	*attach calculation sheets	RADIUS (m)
	Arbitrary Fixed Radius	
Calculated Fixed Radius	(1-year travel time)*	
	(5-year travel time)*	
	(10-year travel time)*	

PARABOLIC CAPTURE ZONE (refer to Appendix 2.2)*

Downgradient distance ____________ m

Width of capture zone ____________ m

Is there a river, lake, pond, stream or other obvious surface water body within the 6-month time of travel boundary? ☐ yes *(identify on map)* ☐ no

Is there a stormwater and/or wastewater facility, treatment lagoon or holding pond located within the 6-month time of travel boundary? ☐ yes *(identify on map)* ☐ no

PART VII: SOURCE SURVEY (Refer to Step 3)

4 REGIONAL SOURCES OF RISK TO GROUND WATER

Please indicate if any of the following potential sources of contamination within the capture zone.

ACTIVITY	T.O.T. NOT SPECIFIED	1-YEAR	5-YEAR	10-YEAR	COMMENTS
Chemical Storage *(specify)*					
Injection wells					
Abandoned wells					
Landfills, dumps, disposal areas					
Commercial/industrial sites					
Known hazardous materials clean-up site					
Household hazardous waste					
Population density > 2 houses per hectare					
On-site sewage treatment					
Wastewater treatment facility					
Sites used for land application of waste					
Golf course					
Dairy or beef farms					
Poultry barns					
Hobby farms					
Fields: vegetables, hay, fruit *(specify)*					
Mining operations					
Gravel pits					

** Mark and identify on map any of the potential sources listed above which are located within the capture zone boundary.

SEPTIC FIELD SETBACK ________ m or ________ ft.

GRADIENT TO SEPTIC FIELD ☐ upgrade ☐ downgrade ☐ same grade ________ % ________ %

DENSITY OF ON-SITE SEWAGE DISPOSAL SYSTEMS

COMMUNITY SYSTEM

SYSTEM PER LOT

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Appendix 1.4 Selection of Base Maps

Local maps (generally 1:5,000 and larger) are usually available from regional or municipal governments. In most incorporated areas, the local source for mapping would be the municipality. Regional district offices also have cadastral or land-use zoning maps. "Cadastral" maps are parcel-based maps with legal information such as district lot and plan lot numbers. Road right-of-ways are usually included but topography and information on watercourses are usually not.

The format and scale vary from one community to another. In small communities, map scales typically vary from 1:1,000 to 1:2,500. Cities are mapped at scales from 1:2,500 to 1:5,000. Most maps will be available in paper copy, or in digital (computerized) format compatible with Geographical Information Systems (GIS). Some larger municipalities may also have some land-use maps available (especially those that use GIS).

Cadastral maps of 1:1,000 to 1:20,000 are usually good base maps.

If there is no mapping available locally, the B.C. Assessment Authority will have maps. B.C. Assessment Authority maps for communities throughout the province can be obtained through Island Blue Print in Victoria at: (250) 385-9786.

TRIM (Terrain Resource Information Management) maps are at a scale of 1:20,000. They show contours, watercourses and other water bodies, and are available for all areas of the province. However, these digital maps are expensive (approximately $600/sheet for a digital file). TRIM maps are available through Land Data BC. Maps can be ordered through Geographic Data BC: http://www.elp.gov.bc.ca/gdbc/

STEP ONE:
Establishing A Community Planning Team

Pumphandle, British Columbia is a small town with 650 residents, located in a valley to the east of Vancouver. Most of the residents work in logging, agriculture, tourism and recreation.

Drinking water comes from three community wells (Figure CS 1.1):

- Aiken's Well, shown as Well A, is a shallow well dug into a spring. At the turn of the century, the property around the well belonged to Rolland Aiken. As the community of Pumphandle grew, the need for a community water supply increased. Rolland Aiken formed the Aiken Waterworks and the family continues to own and operate the waterworks to this day. Water from the well is supplied to the main subdivision in Pumphandle with 165 homes (500 residents), and a number of commercial users including a gas station and dry cleaner.
- The Blackwater Well, shown as Well B, supplies water to another 35 homes (100 residents), and the campground, hotel, schools and golf course.
- Charlie's Well, shown as Well C, provides water to a small new subdivision of 15 homes with approximately 50 residents.

Further up the valley, in areas to the south and west of Pumphandle, residents are served by individual wells and private intakes from the nearby mountain creeks.

Aiken Waterworks had samples taken from Aiken's Well for a complete chemical analysis. In the last few sampling rounds, results from the certified environmental laboratory showed an elevated nitrate concentration in the groundwater (nitrate-nitrogen levels of 7 mg/L). The maximum allowable concentration (MAC) for nitrate-nitrogen is 10 mg/L as set out in the Guidelines for Canadian Drinking Water Quality.

Andrew Aiken contacted Anne Jones, the local Environmental Health Officer, to see if she had any information that could help him protect his well from increasing levels of nitrate in the water. She told him that the aquifer near Aiken's Well was vulnerable to contamination from land-use activities because it is not protected by any surface clay or till layers. She also sent him a copy of the *Well Protection Toolkit*, and suggested that he talk to the other water purveyors in the area to see if they would be interested in developing a well protection plan for the area.

Andrew Aiken met with the water purveyors from the other two community wells. They had also noticed elevated nitrates in their water supply, and agreed that a well protection plan was needed to protect the community's groundwater supply from further contamination. The water purveyors decided to use the *Well Protection Toolkit* as a guide to help them in developing their plan.

Form a Community Planning Team

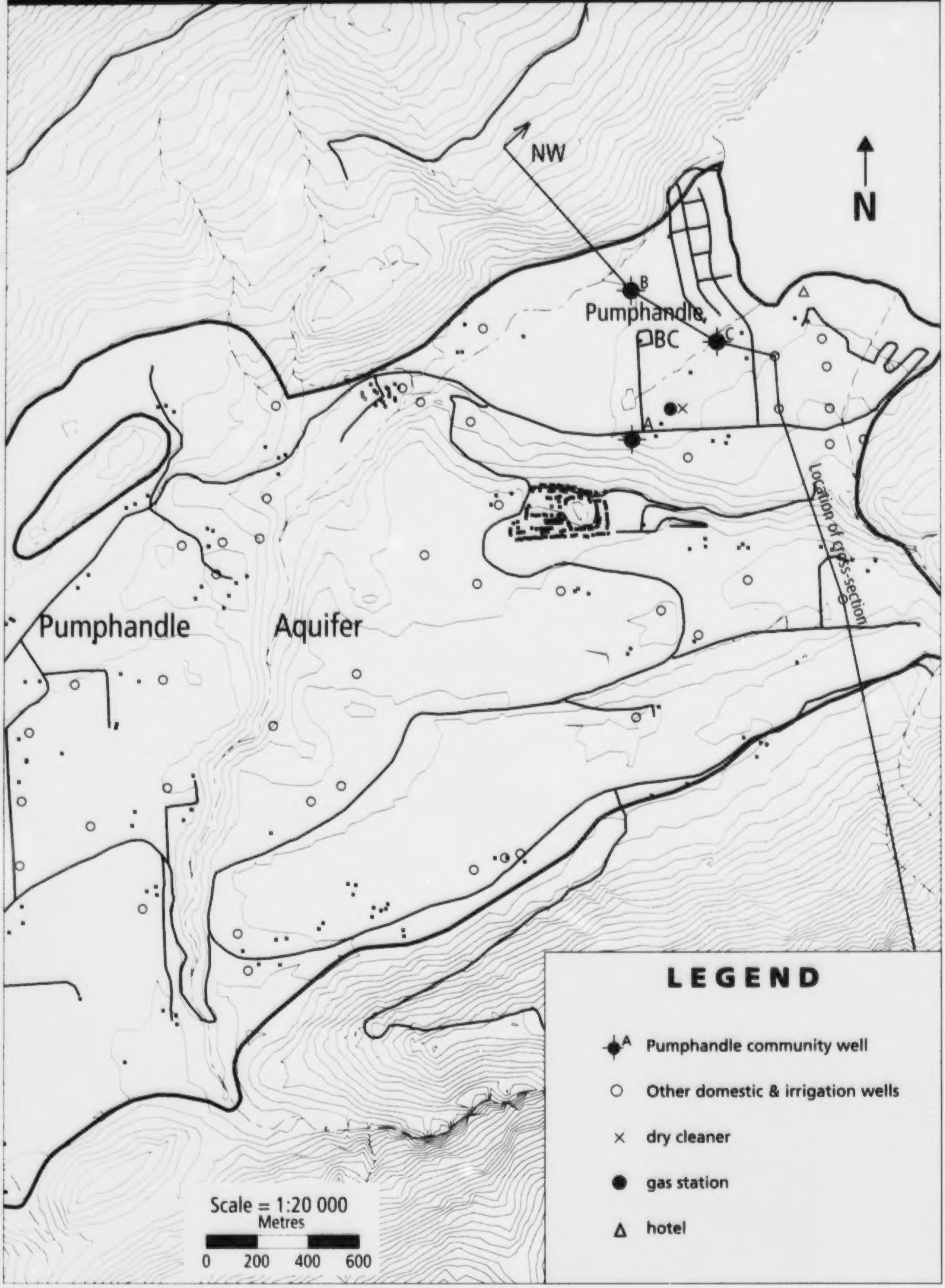
As a first step, the three purveyors prepared a list of individuals and agencies who might be interested in being part of a community planning team and in helping to develop a well protection plan for the entire community.

They called local farmers and the owners of the hotel, trailer campground, golf course, gas station and dry cleaner. The Regional District was asked to provide someone from the Engineering and Planning Department. The Pumphandle Valley Conservation Society was invited, as they could play an important role in raising public awareness of the issue.

Andrew Aiken called Anne Jones and invited her to join the planning team. Andrew also asked Anne if she would represent provincial government interests on the team. He thought that it would be easier for her to be the main contact with staff from other government agencies (such as Agriculture and Environment, Lands and Parks).

In total, eight people agreed to participate on the Pumphandle community planning team:

FIGURE CS 1.1 MAP OF THE PUMPHANDLE AQUIFER


NW
N
B
Pumphandle
BC
C
A
Location of cross-section
Pumphandle
Aquifer
LEGEND
Pumphandle community well
Other domestic & irrigation wells
dry cleaner
gas station
hotel
Scale = 1:20 000
Metres
0
200
400
600

- Andrew Aiken, purveyor for Aiken's Well
- Jenny Lowden, purveyor for Blackwater Well
- Eric Kowski, purveyor for Charlie's Well
- Ian Rutherford, P. Eng., Engineer for Valley Regional District
- Simon Lee, farmer
- Jocelyne Dufour, campground owner/operator
- Devon Alexander, Pumphandle Valley Conservation Society
- Anne Jones, Environmental Health Officer, Pumphandle Community Health Services Society

Andrew Aiken was selected as the team leader. Each team member was given a copy of the *Well Protection Toolkit*. The team agreed to meet every two weeks for the first three months of the process so they could get a good start on the project. At the first "official" meeting, the Pumphandle community planning team would discuss what information was available about the existing wells and the community, and what else would be needed.

Gather and Map Information

The Pumphandle community planning team started by collecting and mapping information about the groundwater supply. They used a 1:20,000 TRIM[5] map as a base map, which was the only digital mapping available for the area (Figure CS 1.1). More detailed 1:2,000 cadastral maps would be used during field studies. Anne Jones (the Environmental Health Officer), Ian Rutherford (District Engineer) and the three purveyors agreed to gather the initial information. They mapped:

- the location of the wells (community and private);
- land use activities (commercial, residential, agricultural, recreation, undeveloped); and
- the boundary of the aquifer (information obtained from the Ministry of Environment, Lands and Parks).

This information was recorded on the well assessment form. There was no available information on the amount of water used for private irrigation, so this would be collected during Step Three.

Anne Jones and Ian Rutherford were unable to find any results of a chemical analysis for pesticides for any of the three wells. They noted the need for a comprehensive agricultural chemical analysis for the wells. This information would provide baseline data, which could be compared with future results.

Set Goals and Objectives

In developing their terms of reference, the Pumphandle team set themselves two long-term goals:

1. To encourage public awareness of the need to protect groundwater; and
2. To develop and implement a well protection plan that will minimize the nitrate levels in the Pumphandle wells and aquifer.

Each long-term goal was broken down into several short-term objectives:

1. **Encourage public awareness and education**
    - produce an information sheet on the well water supplies in Pumphandle;
    - hold public information meetings;
    - conduct a groundwater issues survey;
    - place signs in strategic locations informing the public that they are in a designated well protection area;
    - include groundwater information in the public school education programs; and
    - raise money to assist with publication of educational materials.
2. **Develop a well protection plan**
    - complete the well assessment form for each community well (Step One);
    - delineate the well protection areas for all three community wells (Step Two);
    - conduct a contaminants inventory for all of Pumphandle (Step Three);
    - select and implement groundwater protection measures (Step Four);
    - develop a contingency/emergency response plan (Step Five); and
    - design and implement a monitoring program (Step Six).

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[5] Terrain Resource Information Management

Assign Tasks

The Pumphandle team divided the jobs of meeting these objectives (see Table CS 1.1). They decided that future meetings would be held on a monthly basis and that progress reports on each of the goals would be presented at these meetings.

TABLE CS 1.1 PUMPHANDLE TEAM RESPONSIBILITIES

TASKS	PURVEYORS	DISTRICT ENGINEER	FARMER	CAMPGROUND OWNER	CONSERVATION SOCIETY	ENVIRONMENTAL HEALTH OFFICER
1. Complete the well assessment form	•	•				•
2. Conduct a groundwater issues survey					•	
3. Delineate the capture zones for all three wells	•	•				
4. Conduct a contaminants survey		•			•	•
5. Select and implement groundwater protection measures	•	•	•	•	•	•
6. Produce an information sheet on the well water supplies and aquifer in Pumphandle	•				•	•
7. Fund raising to assist with publication of educational materials			•	•	•	
8. Hold public information meetings	•	•				•
9. Include groundwater in the public education programs					•	•
10. Place signs in strategic locations			•	•		•
11. Develop a spill contingency/emergency response plan	•		•	•		•
12. Design and implement a water quality monitoring program	•	•			•	•

Step Two

DEFINE THE WELL PROTECTION AREA

British Columbia

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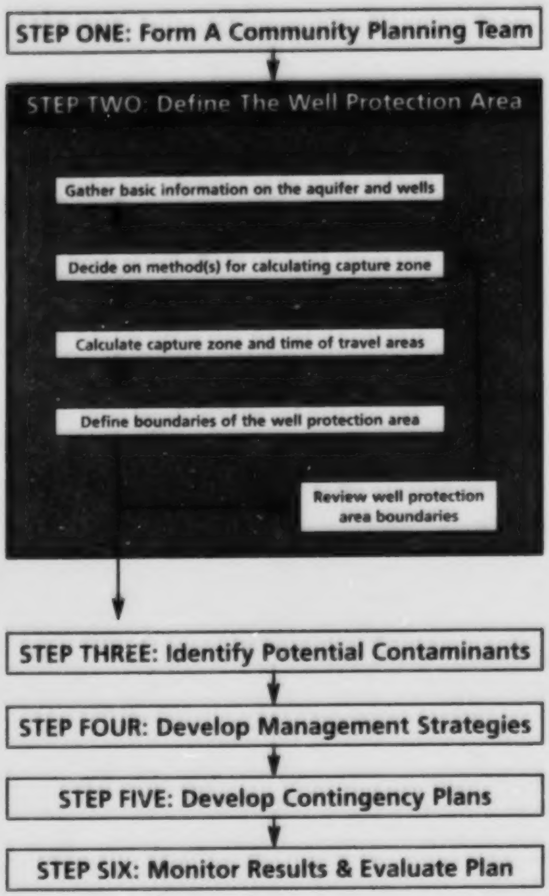
STEP ONE: Form A Community Planning Team
STEP TWO: Define The Well Protection Area
Gather basic information on the aquifer and wells
Decide on method(s) for calculating capture zone
Calculate capture zone and time of travel areas
Define boundaries of the well protection area
Review well protection area boundaries
STEP THREE: Identify Potential Contaminants
STEP FOUR: Develop Management Strategies
STEP FIVE: Develop Contingency Plans
STEP SIX: Monitor Results & Evaluate Plan

More than 750,000 British Columbians rely on groundwater as their source of drinking water, and there are thousands of community well systems in British Columbia. A well protection plan allows communities to identify land use activities that may threaten the quality of their well water, and to develop a strategy to avoid or minimize these threats.

There are six steps to follow in developing a well protection plan:

1. Form a community planning team
2. Define the well protection area
3. Identify potential contaminants
4. Develop and implement management strategies
5. Develop contingency plans
6. Monitor results and evaluate the plan

These steps are described in the six booklets that make up the *Well Protection Toolkit*. Each booklet describes activities that lead to the development and implementation of a well protection plan. In each step, a fictional case study of the town of Pumphandle shows how one community took on this challenge.

Step Two: Define the Well Protection Area

The second step is to define the area that should be managed and protected from potential contamination – the "well protection area." The length of time that it would take contaminants to reach each well is also calculated at this stage. It is a good idea to review the boundaries of the well protection area from time to time, especially if new wells constructed nearby place additional demands on the aquifer and alter the "capture zone" of the community well(s).

Figure 2.1 shows the stages of Step Two.

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Define the Well Protection Area

OBJECTIVES

- To select a method to identify the capture zone for each community well
- To calculate the capture zone and time of travel areas
- To define the boundaries of the well protection area
- To review the boundaries as required

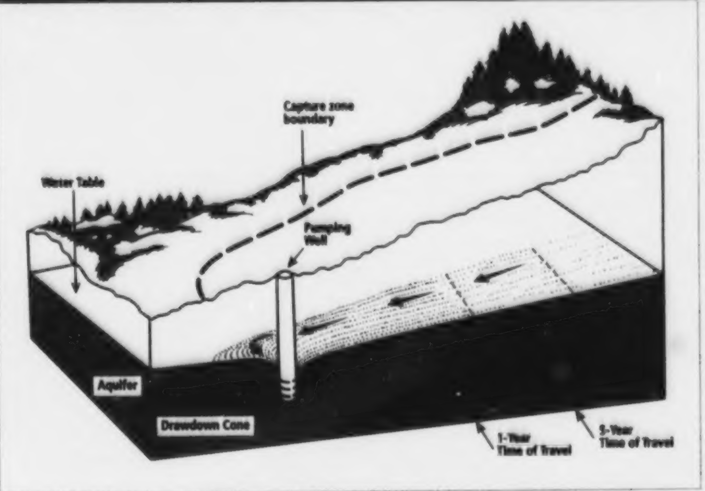
Once the community planning team has some initial information for each community well and aquifer (Step One), the next step is to determine the area that needs to be protected from contamination – the "well protection area."

Step Two is the most technical step in the six-step well protection planning process, and the planning team will probably need professional assistance in completing this work. The information provided here is a general introduction to the methods for determining the well protection area.

2.1 Definitions

The planning team should become familiar with a number of technical terms that will be used throughout the development of the well protection plan. Figure 2.2 shows many of these concepts. The groundwater video, *www.groundwater.protection*, available from your local health authority office, also covers many of these definitions and concepts.

Figure 2.2 Schematic Diagram of a Well Capture Zone



Hydrogeology

Hydrogeology is the study of the flow of water and chemicals through the geological formations.

Aquifer

An aquifer is a permeable geological deposit (such as sand and gravel or fractured bedrock) that holds and yields a supply of water (Figure 2.2). The well may draw water from a large portion of the aquifer, or only part of it.

Aquifer Transmissivity

Aquifer transmissivity refers to the ability of an aquifer to transmit water.

Aquitard

An aquitard is a geological formation that does not transmit a significant amount of water to wells and springs. Some examples of aquitards are sediments such as silts, clays and tills.

Confined Aquifer

Where an aquitard overlies an aquifer, the low permeability of the aquitard can help in protecting the underlying aquifer from impacts of human activities at the land surface. In those cases, an aquifer is said to be "confined."

Unconfined Aquifer

Where no aquitards overlie the aquifer, the aquifer is said to be "unconfined" and is vulnerable to impacts from human activities at the land surface, particularly if the water table is shallow. Knowing which areas of the aquifer are most vulnerable will allow you to put the greatest effort into the areas that need most protection.

Define the Well Protection Area

OBJECTIVES

- **To select a method to identify the capture zone for each community well**
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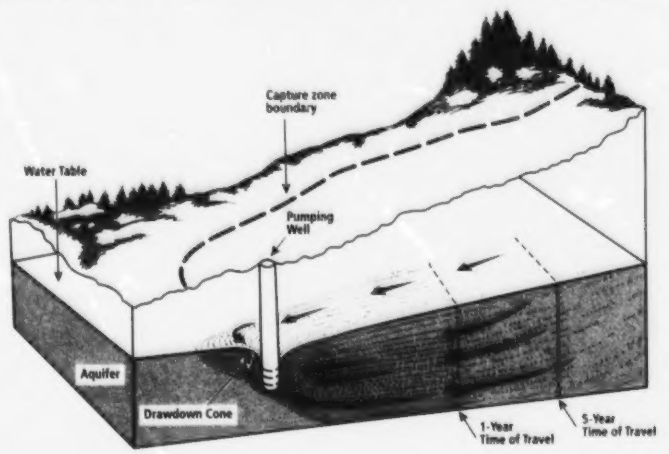
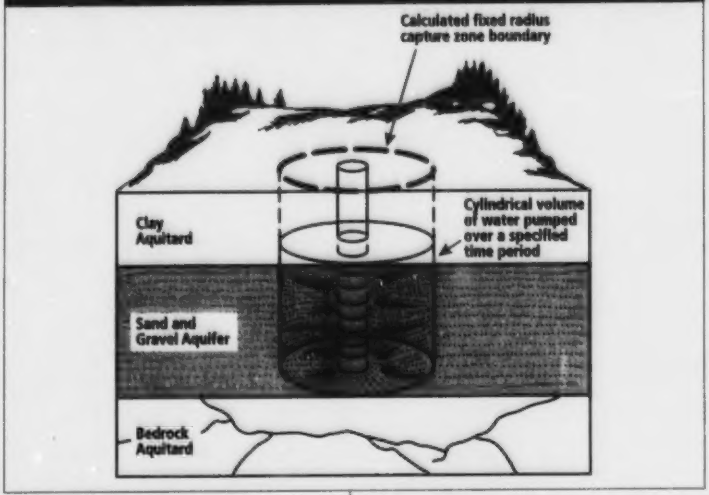


Figure 2.3 Calculated Fixed Radius Capture Zone


Calculated fixed radius capture zone boundary
Clay Aquitard
Cylindrical volume of water pumped over a specified time period
Sand and Gravel Aquifer
Bedrock Aquitard

Water Table

The water table is the level of standing water in the ground (Figure 2.2) and is the upper boundary of the unconfined aquifer. Where the water table comes to the surface, lakes and wetlands form.

Drawdown Cone

When water is pumped from a well, the water table close to the well drops in a cone-shape (see Figure 2.2). The area influenced by the pumping well is called the "drawdown cone." Its shape will vary – it is circular only where the geology is uniform and the water table is level.

Capture Zone

The capture zone is the land area that contributes water to the community well (Figure 2.2). Another name for this is the "recharge area." Any precipitation (rain or snow) that lands in this area may eventually end up in your well water. So may any fertilizers, oils spills or other contaminants. It is important to define the capture zone accurately, because you cannot protect the well water without knowing where that water is coming from.

Well Protection Area

The well protection area is the land area on which protection measures are taken. In most cases, this will be the area defined as the capture zone. However, it may include an area larger than the capture zone (e.g. the water district boundary). It is recommended that the well protection area be reviewed every year and revised as necessary.

Time of Travel (TOT)

The capture zone can be divided into sub-areas based on "time of travel": the time it takes water to flow from a given point to the well. Usually, the capture zone is divided into one-year, five-year and ten-year time of travel (TOT) areas. The one-year TOT area is normally closest to the well; the five- and ten-year TOT areas are further away (Figure 2.2).

There are two reasons for dividing the capture zone into TOT sub-areas:

- It provides the planning team with an idea of the time it would take for contaminants to travel to the well from different areas within the capture zone. Contaminants in the one-year TOT area will take a year or less to reach the well, contaminants spilled in the ten-year TOT area can take up to ten years to reach the well.
- It makes it easier to set priorities. The first priority for protection measures will be in the one-year TOT area. As well, some contaminants (e.g. bacteria) can only travel limited distances in soils before they are filtered out or die off, and are therefore of less concern when they are in the five- or ten-year TOT area.

2.2 Methods to Define the Capture Zone

It is important to define the capture zone accurately. Contaminants in the capture zone could pollute the water supply to the well. There are a number of methods to determine the capture zone, of which many are quite complex and technical (see Appendix 2.1 for a list of publications on this subject). The five methods most commonly used to delineate capture zones are:

1. Arbitrary Fixed Radius (AFR);
2. Calculated Fixed Radius (CFR);
3. Analytical Equations;
4. Hydrogeologic Mapping; and
5. Numerical Flow Modelling.

The community planning team can undertake the first two methods. Analytical equations, hydrogeological mapping and modelling are more complex methods and a qualified hydrogeologist should conduct the analysis.

Arbitrary Fixed Radius and Calculated Fixed Radius

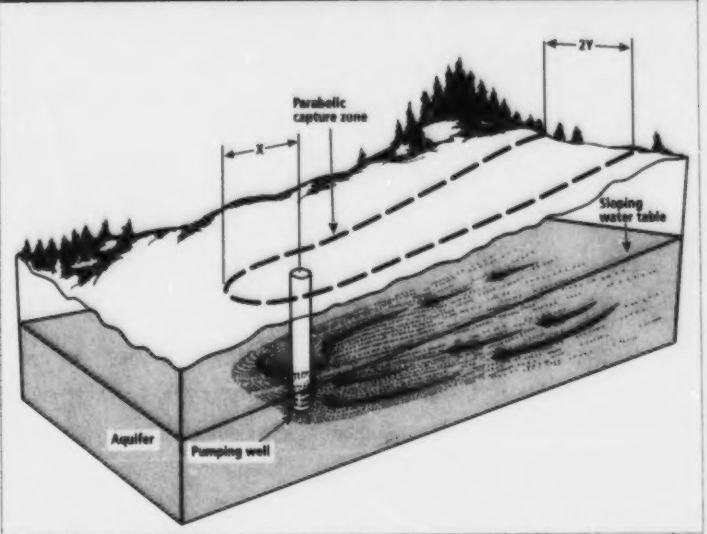
Both the Arbitrary Fixed Radius (AFR) and Calculated Fixed Radius (CFR) methods define the capture zone by drawing a circle around the wellhead. The difference between the two methods is that the circular AFR area is based solely on a fixed distance from the wellhead, while the area for the CFR is calculated using the volume of water pumped.

The AFR usually covers the area within 300 metres of the wellhead. This capture zone covers land beyond the immediate area of the well, but is not so large that management of the well protection area becomes too difficult. Major disadvantages of this method are that it is arbitrary, and the circular area cannot be subdivided into time of travel areas. The AFR should be used as a temporary measure and only where no information exists on the water use, well, or the aquifer.

The CFR calculates a circular area (Figure 2.3), based on the volume of water pumped by the well over a specified period of time (e.g. one, five or ten years). This reflects the time it takes a contaminant to travel from the CFR boundary to the well, based on the pumping rate (see Appendix 2.2 for details).

The CFR method is suitable for sand and gravel aquifers, where the water table is relatively level and wells supply no more than 100 connections.

Figure 2.4 Capture Zone in an Aquifer with a Sloping Water Table



Analytical Equations

Where the water table is sloping, the fixed radius methods do not work. The shape of the capture zone around the pumping well is no longer circular, as recharge to the well come from "up-gradient" and has a long, finger-like shape (Figure 2.4).

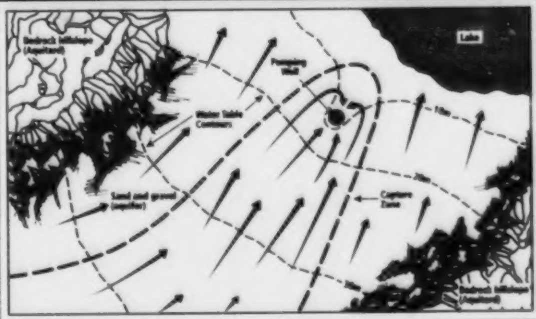
Simple equations have been developed for delineating capture zones where the water table is sloping. Formulas for calculating the dimensions of the capture zone and time of travel boundaries are presented in Appendix 2.3.

Analytical equations are suitable for sand and gravel aquifers where conditions are uniform and there is sufficient information on the pumping rate, aquifer transmissivity, and water table slope. This method may not work well for fractured bedrock aquifers.

Hydrogeologic Mapping

Hydrogeologic mapping locates and maps the groundwater flow. The capture zone is defined by identifying the aquifers and aquitards, mapping the groundwater levels, and then determining flow

Figure 2.5 Capture Zone Delineated by Hydrogeologic Mapping


Bedrock hillslope (Aquitard)
Lake
Pumping well
Water Table Contours
Sand and gravel (aquifer)
Capture Zone
Bedrock hillslope (Aquitard)

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DEFINING THE CAPTURE ZONE

A city in the Lower Fraser Valley used to obtain its water supply from both municipal wells and from surface water. With increasing concerns over surface water pollution, the city phased out the use of surface water and relied solely on well water.

The city decided to develop a well protection plan. In 1995, preliminary capture zones for the wells were delineated using simple methods, as part of a groundwater monitoring study for the entire Lower Fraser Valley (Carmichael et al, 1995[1]). In 1997, the city hired a groundwater consultant to refine these capture zones and identify capture zones for their new wells. The consultant developed a numerical groundwater flow model of the aquifer, based on present and future water demands. This determined which areas feed water to the wells.

Although the numerical modelling was more expensive, it was also more accurate. This model also showed that the time of travel for contaminants was less than five years for four of the six wells, leaving little time for the city to respond to contamination events. For one well, the TOT was less than one year. Managing potential contaminant sources will be especially critical for these four wells.

The city also developed a groundwater vulnerability map to assess the need for aquifer-wide protection. Mapping showed the aquifer is highly vulnerable to contamination and a plan to manage the land use activities above the aquifer was critical to ensuring a safe, long-term groundwater supply.

directions from water level contours[2] (Figure 2.5). This method requires considerable expertise and should be carried out with the assistance of a professional hydrogeologist.

This method is particularly suitable for shallow sand and gravel aquifers where ambient groundwater flow directions can be directly implied from topography and where the surface geology can be used to identify aquifer boundaries.

Numerical Modelling

Numerical modelling develops and uses computer models of the groundwater flow system. Information on the hydrogeology of the area is entered into a computer program, which calculates the water level, flow rates, and flow directions. This information is used to define the capture zone for the well and time of travel of the contaminants.

The main advantage of numerical modelling is that it can combine variations in hydrogeology and pumping conditions, which analytical equations and other simpler methods can not. However, considerable amounts of data, technical expertise, and interpretation are required to develop a numerical model and it is a relatively costly technique to use. Professional assistance will be needed.

Developing a numerical model requires large amounts of data, so it may not be practical to develop models for areas of the province where data are scarce. However, the capabilities of computer models make them a valuable tool for on-going resource management and contingency planning. For (larger) communities with good data and the resources to develop and maintain a computer model, this type of model is an excellent long-term investment.

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[1] Carmichael, V., M. Wei, and L. Ringham, 1995. *Fraser Valley Groundwater Monitoring Program.* Province of British Columbia.

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2.3 Calculate the Capture Zone and TOT Areas

Select a Method

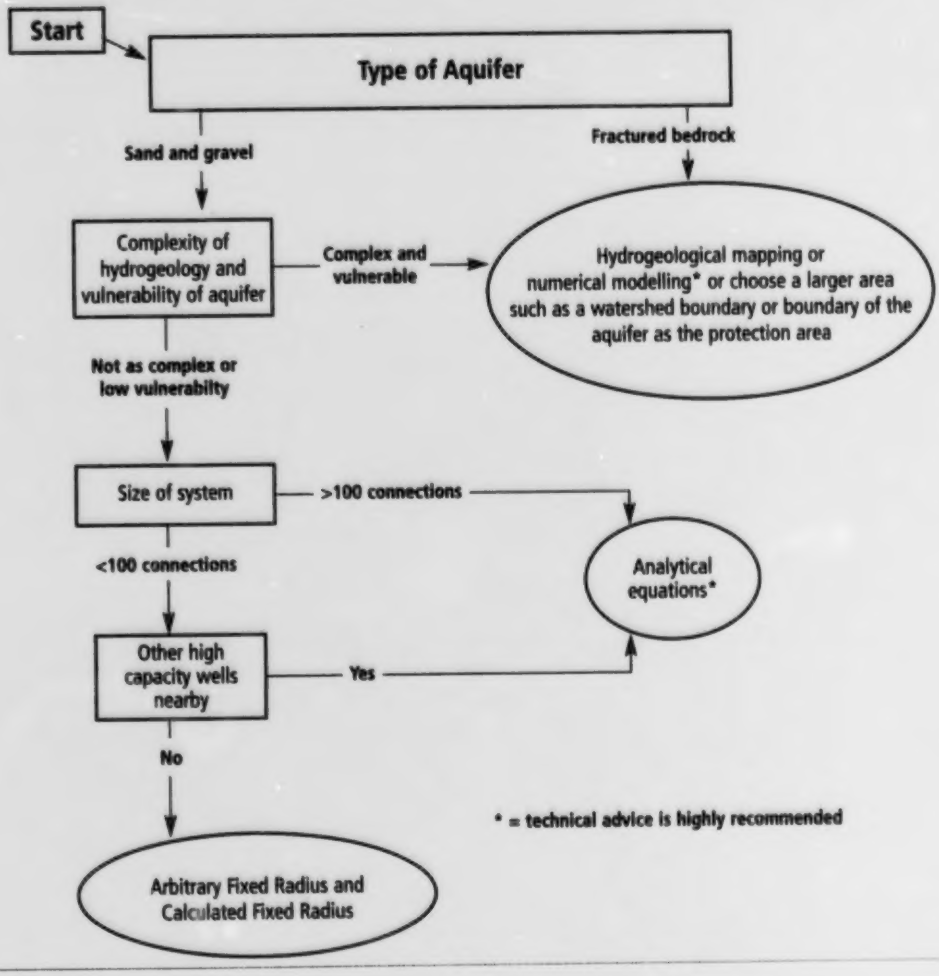
How do you decide which of the five methods to use? Some of the advantages and disadvantages are listed in Table 2.1.

Although it is tempting to use simple and less expensive methods (such as AFR), they are based on very simplistic assumptions. These assumptions may not apply in your situation, and could result in the planning team wasting resources on protection measures in an area that contributes little or no water to the groundwater supply. Experience in the United States shows that people may challenge your defined capture zone, because of the cost of implementing protection measures, and you will need to be able to justify your decisions.

However, AFR and CFR may be useful as interim methods to allow well protection planning to get underway. Once the community sees the value of groundwater protection and supports it, you may find additional funding to refine the capture zone using more accurate methods.

You should attempt to delineate the capture zone as accurately as possible, based on the information and funding available, local conditions and size of the water system. Figure 2.6 will help you to determine

Figure 2.6 Criteria for Selecting Capture Zone Delineation Methods


Start
Type of Aquifer
Sand and gravel
Fractured bedrock
Complexity of hydrogeology and vulnerability of aquifer
Complex and vulnerable
Hydrogeological mapping or numerical modelling* or choose a larger area such as a watershed boundary or boundary of the aquifer as the protection area
Not as complex or low vulnerabilty
Size of system
>100 connections
<100 connections
Analytical equations*
Other high capacity wells nearby
Yes
No
Arbitrary Fixed Radius and Calculated Fixed Radius

* = technical advice is highly recommended

TABLE 2.1: SUMMARY OF CAPTURE ZONE DELINEATION METHODS

METHOD	EXPLANATION	ASSUMPTIONS
Arbitrary fixed radius	Assign circular area of fixed radius (300 m) around well	- uniform aquifer - negligible ambient flow
Calculated fixed radius See Figure 2.3	Calculate cylindrical volume of aquifer supplying water to well for a given pumping rate and time period See Appendix 2.2	- uniform aquifer - negligible ambient flow
Analytical equations See Figure 2.4	Calculate capture zone dimensions using analytical equations accounting for uniform ambient flow See Appendix 2.3	- uniform aquifer - horizontal, steady-state flow - uniform ambient flow - capture zone does not extend beyond watershed divide
Hydrogeologic mapping See Figure 2.5	Map capture zone from measured groundwater level contours and geomorphologic, topographic and hydrologic features	- groundwater flow direction same as topographic slope - horizontal flow
Numerical modelling	Delineate capture zone using numerical flow modelling incorporating actual hydrogeologic information	- depends on the model

TYPICAL DATA REQUIRED	ADVANTAGES/DISADVANTAGES	WHEN APPLICABLE
None	ADVANTAGES: • easy and inexpensive to apply DISADVANTAGES: • arbitrary • may be difficult to defend	Inadequate information on well construction, pumping rate and hydrogeology; typically used for drive points and dug wells
- pumping rate and/or water use - aquifer thickness (or well screen length) - aquifer porosity	ADVANTAGES: • easy and inexpensive to apply • accounts for some site-specific information DISADVANTAGES: • based on simple physical assumptions	Well construction and pumping rate are known, hydraulic gradient is low and aquifer thickness can be estimated; not appropriate for fractured bedrock aquifers
- pumping rate and/or water use - aquifer transmissivity - ambient hydraulic gradient - aquifer porosity - aquifer boundary	ADVANTAGES: • easy and inexpensive to apply • accounts for some local information DISADVANTAGES: • based on simple physical assumptions	Aquifer transmissivity and pumping rate are known and a uniform hydraulic gradient can be estimated; may not be appropriate for fractured bedrock aquifers
- aquifer boundary - water table contours (or topographic contours) - geology - water quality	ADVANTAGES: • accounts for local information • physically based DISADVANTAGES: • moderate - expensive to apply • large data requirement	May be especially useful for shallow, unconfined aquifers, springs, as well as karstic and fractured bedrock aquifers
- aquifer boundary - geology - water level elevations - aquifer transmissivity - hydraulic conductivity of aquitards - knowledge of boundary conditions	ADVANTAGES: • accounts for local information • physically based • predictive capability DISADVANTAGES: • moderate - expensive to apply • large data requirement	Where hydrogeology and groundwater conditions can't be adequately represented by simple analytical models (e.g. bedrock aquifers or complex hydrogeology and vulnerable aquifers)

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- pumping rate and/or water use - aquifer thickness (or well screen length) - aquifer porosity	**ADVANTAGES:** • easy and inexpensive to apply • accounts for some site-specific information **DISADVANTAGES:** • based on simple physical assumptions	Well construction and pumping rate are known, hydraulic gradient is low and aquifer thickness can be estimated; not appropriate for fractured bedrock aquifers
- pumping rate and/or water use - aquifer transmissivity - ambient hydraulic gradient - aquifer porosity - aquifer boundary	**ADVANTAGES:** • easy and inexpensive to apply • accounts for some local information **DISADVANTAGES:** • based on simple physical assumptions	Aquifer transmissivity and pumping rate are known and a uniform hydraulic gradient can be estimated; may not be appropriate for fractured bedrock aquifers
- aquifer boundary - water table contours (or topographic contours) - geology - water quality	**ADVANTAGES:** • accounts for local information • physically based **DISADVANTAGES:** • moderate - expensive to apply • large data requirement	May be especially useful for shallow, unconfined aquifers, springs, as well as karstic and fractured bedrock aquifers
- aquifer boundary - geology - water level elevations - aquifer transmissivity - hydraulic conductivity of aquitards - knowledge of boundary conditions	**ADVANTAGES:** • accounts for local information • physically based • predictive capability **DISADVANTAGES:** • moderate - expensive to apply • large data requirement	Where hydrogeology and groundwater conditions can't be adequately represented by simple analytical models (e.g. bedrock aquifers or complex hydrogeology and vulnerable aquifers)

TABLE 2.2 SUMMARY OF AVAILABLE GROUNDWATER INFORMATION

DATA/ INFORMATION	PURVEYOR OR CONSULTANT	WELL DATABASE/ WELL LOCATION MAPS (MELP)[3]	DRILLER/ PUMP INSTALLER	WSACS[4] DATABASE (MOH[5])	OBSERVATION WELL NETWORK DATA (MELP)	GROUNDWATER REPORTS[6] (MELP)	AQUIFER CLASSIFICATION MAPS (MELP)	OTHER GEOLOGICAL/ HYDROLOGICAL MAPS	WHAT TO DO IF INFORMATION IS NOT ALREADY AVAILABLE?
Well lithology, construction and capacity	■	■	■	●					If well record for the community well cannot be obtained, can estimate lithology from well records of adjacent wells; determine well depth and screen location by sounding the well; measure capacity using a pumping test
Well pumping rate	■	■	●						Pumping rate can be measured by the purveyor or estimated based on the number of connections
Groundwater conditions and water level at well	■	■	■		●				Pumping and static water levels can be measured by purveyor if access at the wellhead is available
Transmissivity at the well	■	■				■			Transmissivity can be estimated by a pumping test or from specific capacity data*
Well water quality	■	●		■					Water chemistry can be characterized by collecting samples from the well for laboratory analysis (consult MOH about chemical parameters to analyze)
Groundwater conditions and water level in the aquifer		■	●		■	■			Groundwater reports exist for specific areas only; in most areas, groundwater conditions and water levels can be determined by compiling information from well records and conducting field surveys*
Transmissivity and thickness of the aquifer		■			●	■			Information exist for specific areas only, in other areas, this information can be compiled from well record data*

TABLE 2.2 SUMMARY OF AVAILABLE GROUNDWATER INFORMATION CONTINUED

DATA/ INFORMATION	PURVEYOR OR CONSULTANT	WELL DATABASE/ WELL LOCATION MAPS (MELP)	DRILLER/ PUMP INSTALLER	WSACS DATABASE (MOH)	OBSERVATION WELL NETWORK DATA (MELP)	GROUNDWATER REPORTS (MELP)	AQUIFER CLASSIFICATION MAPS (MELP)	OTHER GEOLOGICAL/ HYDROLOGICAL MAPS	WHAT TO DO IF INFORMATION IS NOT ALREADY AVAILABLE?
Water quality of aquifer and capacity		●		■	●	■	■		Where inadequate information exists, a field sampling survey required*
Location of aquifer		●				■	■		Surficial geology maps can be used to infer location of shallow, unconfined surficial aquifers*
Vulnerability of aquifer		●				■	■	●	Aquifer vulnerability maps exist for specific areas only; surficial geology maps can be used to infer shallow, unconfined surficial aquifers that are highly vulnerable to contamination*
Groundwater flow directions		■				■			Groundwater reports exist for specific areas only; in most areas, flow directions can be determined by compiling water level information from well records and measuring water levels in the field*
Recharge/ discharge areas		■				■			Information on recharge/discharge areas rarely exist; in most areas, this is inferred by compiling water levels from well records and also from vegetation maps*

■ = major source of information; ● = minor source of information; * = consult a professional hydrogeologist

[3] MELP: Ministry of Environment, Lands and Parks, [4] WSACS: Water Sampling Analysis Computer System, [5] MOH: Ministry of Health, [6] On National Topographic System (NTS) file and from consultants.

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Well pumping rate	■	■	●						Pumping rate can be measured by the purveyor or estimated based on the number of connections
Groundwater conditions and water level at well	■	■	■		●				Pumping and static water levels can be measured by purveyor if access at the wellhead is available
Transmissivity at the well	■	■				■			Transmissivity can be estimated by a pumping test or from specific capacity data*
Well water quality	■	●		■					Water chemistry can be characterized by collecting samples from the well for laboratory analysis (consult MOH about chemical parameters to analyze)
Groundwater conditions and water level in the aquifer		■	●		■	■			Groundwater reports exist for specific areas only; in most areas, groundwater conditions and water levels can be determined by compiling information from well records and conducting field surveys*
Transmissivity and thickness of the aquifer		■			●	■			Information exist for specific areas only, in other areas, this information can be compiled from well record data*

TABLE 2.2 SUMMARY OF AVAILABLE GROUNDWATER INFORMATION CONTINUED

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Location of aquifer		●				■	■		Surficial geology maps can be used to infer location of shallow, unconfined surficial aquifers*
Vulnerability of aquifer		●				■	■	●	Aquifer vulnerability maps exist for specific areas only; surficial geology maps can be used to infer shallow, unconfined surficial aquifers that are highly vulnerable to contamination*
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[3] MELP: Ministry of Environment, Lands and Parks, [4] WSACS: Water Sampling Analysis Computer System, [5] MOH: Ministry of Health, [6] On National Topographic System (NTS) file and from consultants,

which method might be most appropriate for your situation. For example, if your community is tapping a well in a sand and gravel aquifer where the geology is relatively simple and the water system has over 100 connections, then it may be appropriate to use analytical equations. However, you may choose to use methods that are more accurate such as hydrogeologic mapping or numerical modelling, especially in populated areas where the capture zone boundary may need to be pinpointed more accurately. Technical advice on which method to use is available from the Ministry of Environment, Lands and Parks in Victoria or groundwater consultants.[7]

Gather Information and Conduct Analysis

In order to define the capture zone and well protection area, it is necessary to collect available information on each community well and on the groundwater resources in the local region. Much of this information may already exist. Table 2.2 (page 10) summarizes sources of this information and ways to obtain the missing information.

The well assessment form (Appendix 1.3) will guide you in compiling information on the well, water system, and local groundwater conditions. The Groundwater Section of the Ministry of Environment, Lands and Parks in Victoria may also be able to provide advice on compiling groundwater information (Appendix 1.2).

You will also need information on the vulnerability of the aquifer. The vulnerability of the aquifer to contamination from land use activities is needed to assess the threat of contamination as part of Step Three. The Ministry of Environment, Lands and Parks is mapping the boundaries of developed aquifers in major groundwater regions of the province and classifying them with respect to vulnerability. Maps of aquifers at 1:20,000 to 1:50,000 scale can be obtained from the Groundwater Section of the Ministry of Environment, Lands and Parks at a nominal cost.

Seek Technical Expertise

Do you need to hire a groundwater consultant to help delineate the capture zone? As a rule, where the delineation involves methods other than AFR and CFR, it is recommended that a groundwater consultant be hired to assist in this work.

The following series of questions may provide some guidance:

- Is your community well in a fractured bedrock aquifer?[8]
- Is there more than one well in the system, and are they located close to each other (e.g. less than 100 metres)?
- Are there other significant pumping wells in close proximity to the community well (less than 100 m)?
- Is your community well supplying a significant number of customers (tens or hundreds of connections)?
- Are the local hydrogeologic conditions complex?[9]

If your answer to any of these is "yes," hiring a groundwater consultant to assist in delineating the capture zone is a good idea (see Appendix 2.4).

You will almost certainly need professional assistance if your aquifer is in fractured bedrock. Groundwater flow in many bedrock aquifers occurs through discrete fractures or through discrete zones, and flow in these aquifers is usually hard to predict. Therefore, capture zones for wells drilled in fractured bedrock aquifers require more data and greater hydrogeologic expertise to analyze. It is likely that hydrogeologic mapping or numerical modelling methods will be needed to delineate the capture zone.

2.4 Set the Boundaries of the Well Protection Area

Now that the planning team has a reasonable idea of where the capture zone and time of travel zones are, you can decide on an appropriate well protection area.

Remember that capture zone boundaries are never determined with complete certainty, because complete information is never available. A common

[7] A list of groundwater consultants in B.C. can be found in the Ministry of Environment, Lands and Parks' Groundwater Home Page (http://www.elp.gov.bc.ca/wat/gws/).

[8] Refer to the well record or well assessment form.

[9] Seek advice from the Groundwater Section of Ministry of Environment, Lands and Parks in Victoria.

way to address this uncertainty is to assume worst case conditions in delineating the well protection area – for example by using the maximum pumping rate of the well to calculate the capture zone. Another way is to delineate the capture zone using several methods to see if the capture zones cover similar areas.

If you cannot determine the capture zone with any degree of certainty (e.g. because of the complex geology), a third option is to establish a well protection area that covers an area larger than the defined capture zone. This larger area may be the watershed boundary, boundary of the aquifer (capture zone boundaries should not extend beyond the aquifer) or the entire water district boundary.

You can establish some priorities at this stage, based on your understanding of the aquifer. For example, you may decide to focus your efforts on areas within the one-year time of travel area and/or in areas known to be vulnerable. Determining the capture zone for a well or group of wells can be challenging. Hiring a groundwater consultant to assist in this process can be a solid investment for future protection activities and help you support your choices and decisions within your community.

2.5 Review the Well Protection Boundaries

The planning team should review the boundaries of the well protection area from time to time. Water use conditions change. When establishing the well protection area, look at the effects of expanding the water supply system. If the demand for water in the community increases, the pumping rate for one or more of the community wells will increase, and so will the size of the capture zone. Any new wells located in the capture zone may also significantly change the capture zone boundaries.

As additional and more recent data becomes available, the understanding of the aquifer and groundwater conditions will increase. The well protection area may need to be adjusted to include this new information.

The existence of higher capacity wells near the community well can affect the capture zone of the community well. In cases where high capacity wells (e.g. other municipal wells, irrigation wells) are known to exist, these wells need to be considered when defining the capture zone of the community well. Review the capture zone annually and see if new high capacity wells exist. If so, then it will be necessary to review the capture zone and revise its boundaries if needed. This is where the use of a numerical model is advantageous because as conditions change, the model can be updated to see how changes (or proposed changes) will affect the capture zone. The advice of a professional hydrogeologist is recommended.

CHECKLIST FOR STEP TWO

The following is a basic checklist for action items to be completed during Step Two of the well protection planning process:

ACTION ITEM	COMMENTS	COMPLETED
Determine the vulnerability of the aquifer in the well protection area	**Get advice from the Ministry of Environment, Lands and Parks or hire a groundwater consultant.**	☐
Decide if you need a groundwater consultant to help with delineating the capture zone	**Go over Figure 2.6 and Section 2.3.**	☐
Develop terms of reference for hiring a groundwater consultant	**Refer to Appendix 2.4.**	☐
Calculate capture zone and TOT	**Choose the appropriate method (Table 2.1); get advice from MELP.**	☐
Define boundaries of well protection area	**Use conservative assessments to account for unknowns.**	☐
Review the boundaries	**Adjust boundaries to account for new wells, increases in pumping requirements, etc.**	☐

way to address this uncertainty is to assume worst case conditions in delineating the well protection area – for example by using the maximum pumping rate of the well to calculate the capture zone. Another way is to delineate the capture zone using several methods to see if the capture zones cover similar areas.

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Develop terms of reference for hiring a groundwater consultant	Refer to Appendix 2.4.	☐
Calculate capture zone and TOT	Choose the appropriate method (Table 2.1); get advice from MELP.	☐
Define boundaries of well protection area	Use conservative assessments to account for unknowns.	☐
Review the boundaries	Adjust boundaries to account for new wells, increases in pumping requirements, etc.	☐

Appendix 2.1 Publications Describing Methods for Determining Capture Zones

Methods for delineating capture zones are described in detail in a variety of publications, including:

Carmichael, V., M. Wei, and L. Ringham, 1995. *Fraser Valley Groundwater Monitoring Program*. Province of British Columbia.

Delin, G. N. and J. E. Almendinger, 1993. *Delineation of Recharge Areas for Selected Wells in the St. Peter-Prairie du Chien-Jordan Aquifer, Rochester, Minnesota.* U.S. Geological Survey Water-Supply Paper 2397. 39 pp.

Franke, O.L., T.E. Reilly, D.W. Pollock and J.W. LaBaugh, 1998. *Areas Contributing Recharge to Wells, Lessons from Previous Studies.* U.S. Geological Survey Circular 1174, 14pp.

Kreye, R., M. Wei, and D. Reksten, 1996. *Defining the Source Area of Water Supply Springs.* Ministry of Environment, Lands and Parks, Hydrology Branch.

Risser, D. W. and G. J. Barton, 1995. *A Strategy for Delineating the Area of Groundwater Contribution to Wells Completed in Fractured Bedrock Aquifers in Pennsylvania.* U.S. Geological Survey Water-Resources Investigations Report 95-4033, 30 pp.

Springer, A. E. and E. S. Bair, 1992. "Comparison of Methods Used to Delineate Capture Zones of Wells: 2. Stratified-Drift Buried-Valley Aquifer". *Ground Water*, 30(6), p. 908-917.

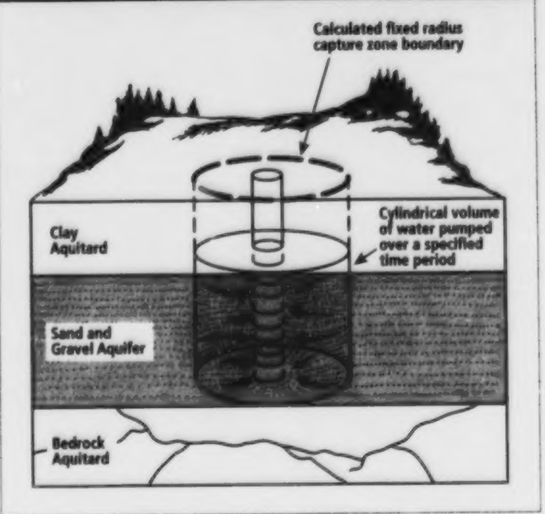
U.S. Environmental Protection Agency, 1994. *Ground Water and Wellhead Protection Handbook.* EPA/625/R-94/001 report, 269 pp.

U.S. Environmental Protection Agency, 1993. *Wellhead Protection: A Guide for Small Communities.* EPA/625/R-93/002 report, 144 pp.

U.S. Environmental Protection Agency, 1987. *Guidelines for Delineation of Wellhead Protection Areas.* EPA/440/6-87/010 report.

Appendix 2.2 Formula for Calculated Fixed Radius

Figure 2.7 Capture Zone Based on Calculated Fixed Radius


Calculated fixed radius capture zone boundary
Clay Aquitard
Cylindrical volume of water pumped over a specified time period
Sand and Gravel Aquifer
Bedrock Aquitard

The formula for calculating the capture zone radius of the volume of water pumped from a pumping well (see Figure 2.7) is:

$$r = \sqrt{\frac{10038\ Q\ t}{n\ b}} \tag{2.1}$$

WHERE:

r = calculated radius around the pumping well (m)

Q = pumping rate (L/s)

- estimated by averaging the volume of water pumped annually
- estimated by assuming the amount of water used is approximately 2270 L/d (500 Igal/d) per connection or per household
- estimates can be checked against the reported well capacity and the pump rating; the well can not be pumped at a higher rate than its capacity nor the capacity of the pump

t = allowed travel time to the well (years)

- usually specified for one-year, five-year and ten-year period

n = aquifer porosity

- or sand and gravel aquifers, n can be assumed to be about 0.25

b = aquifer thickness or screen length (m)

- estimated from the well record(s) and hydrogeologic cross-sections of the local area
- where the aquifer thickness is unknown, the screen length may be used
- the radius calculated using the screen length is larger than the radius calculated using the aquifer thickness and so is a more conservative figure

USE:

- Best suited for sand and gravel aquifers, where the water table is relatively flat.
- Best for wells that supply no more than 100 connections. For larger systems, more physically based capture zone methods such as hydrogeologic mapping and numerical modelling should be considered.
- May not be suitable for fractured bedrock aquifers where groundwater flow occurs through fractures.

Figure 2.8 shows how the CFR increases with increasing water use for a typical sand and gravel aquifer and a well screen of 1.2 m for one-, five- and ten-year periods. The amount of water used is represented by the pumping rate or number of connections the well supplies. A typical value for water use for a residential household is 2270 L/d (500 Igpd). To estimate the radius, simply determine the number of connections or the pumping rate along the Y axis in Figure 2.8, move horizontally to the one- five- or ten-year TOT line and then vertically down to the X axis to determine the radius for a particular time period. For example, a well that supplies 10 connections (0.26 L/s, based on 2270 L/d per connection) would have a CFR of 210 m for a five-year time period.

Figure 2.8 Calculated Fixed Radius Based on Water Use

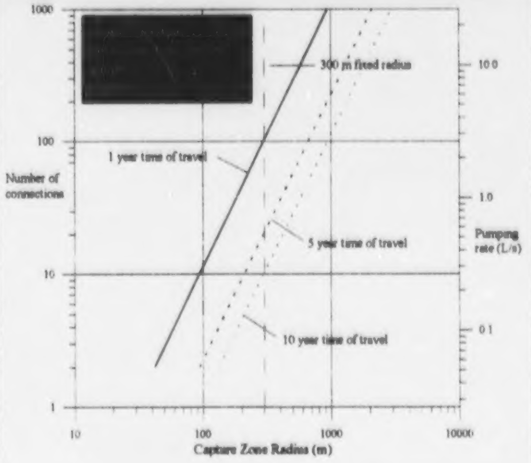
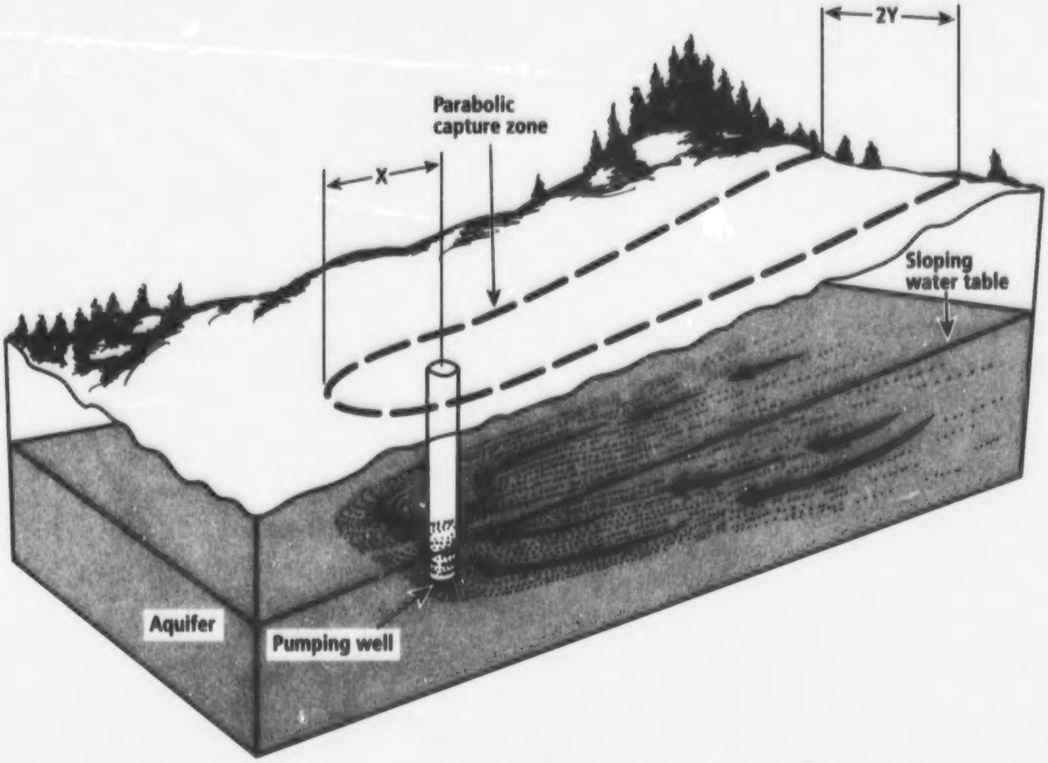


Figure 2.9 Capture Zone Determined from Analytical Equations



Appendix 2.3 Formulas for Analytical Equations

For aquifers that have a uniform ambient water table slope, the distance of the capture zone boundary (X) down-gradient of the pumping well and the width (2Y) of the capture zone up-gradient of the pumping well can be calculated as follows (see Figure 2.9):

$$Y = \frac{Q}{2000\ T\ i} \qquad (2.2)$$

$$X = \frac{Y}{\pi} \qquad (2.3)$$

WHERE:

Y = the half width of the capture zone (m)

X = distance to the capture zone boundary down-gradient of the pumping well (m)

Q = pumping rate (L/s)
- estimated by averaging the volume of water pumped annually
- estimated by assuming the amount of water used is approximately 2270 L/d (500 Igal/d) per connection or per household
- estimates can be checked against the reported well capacity and the pump rating; the well can not be pumped at a higher rate than its capacity nor the capacity of the pump

T = transmissivity of the aquifer (m^2/s)
- measured by conducting a constant rate pumping test and measuring the drawdown in the water level in the aquifer
- transmissivity values may be available from the original groundwater consultant's report
- estimated from the well's specific capacity (see Driscoll, 1986[10])

i = slope of the regional water table or hydraulic gradient under non-pumping conditions
- measured from water table or groundwater level contour maps
- often estimated from the local topographic slope

USE:

- Suitable for sand and gravel aquifers where conditions are uniform and there is sufficient information on the pumping rate, aquifer transmissivity, and water table slope;
- May not be suitable for fractured bedrock aquifers where groundwater flow occurs in discrete fractures.

The distance to the one-, five- and ten-year time of travel boundary in the capture zone can be estimated from the following formula:

$$d_{TOT} = \frac{t\ K\ i}{n} \qquad (2.4)$$

WHERE:

d_{TOT} = the distance representing the one-, five or ten-year time of travel (m),

t = specified time of travel (one, five, ten years),

K = hydraulic conductivity of the aquifer (m/y),
- hydraulic conductivity of the aquifer is the transmissivity divided by the aquifer thickness

i = slope of the water table or hydraulic gradient, and
- measured from water table or groundwater level contour maps
- often estimated from the local topographic slope

n = porosity of the aquifer.
- for sand and gravel aquifers, n can be assumed to be about 0.25

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[10] Driscoll, F.G., 1986. *Groundwater and Wells.* 2nd ed. Johnson Division, St. Paul, Minnesota. 1089 pp.

M121

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Appendix 2.4 General Terms of Reference for Delineating the Capture Zone

When hiring a groundwater professional, you will need to draft specific terms of reference for the work to be performed. Only general terms of reference are provided here. Specific terms of reference depend on site-specific conditions and factors and can only be developed after these are adequately known. It may be desirable to contact the Groundwater Section of the Ministry of Environment, Lands and Parks for advice in drafting specific terms of reference. General terms of reference for characterizing the hydrogeologic setting and delineating the capture zone for the community well include the following:

- Review all available existing data (provide list of information sources) to map and characterize the hydrogeologic setting, including location of aquifers and aquitards, flow direction, hydraulic gradient, lithology, permeability, and water use.
- Develop conceptual model of hydrogeology and flow to wells.
- Identify areas of data/information insufficiencies and their effects on capture zone delineation and outline methods for obtaining additional data/information critical to capture zone delineation and include costs.
- Delineate capture zone(s) for wells based on one-, five-, and ten-year time of travel and zone of contribution to a sufficient degree of certainty. Use the most appropriate delineation method(s) to establish capture zone boundaries. Identify any limitations or uncertainties of delineation, as well as what additional work may be required to address this. When using numerical modelling for delineating the capture zone, consideration should be given to delineating the entire capture zone so the ultimate source of recharge is identified.
- Provide a draft report, discussing work done, actions, and recommendations for review and include maps, models, and databases. Attend meetings to discuss report. Finalize report and assist planning team in presentation of findings to the public and other agencies.

SELECTING A CONSULTING ENGINEER

The Consulting Engineers of British Columbia has a publication titled *A Guide to Selecting a Consulting Engineer*. It describes ways of methodically selecting the right consultant for a project. The "Two-Envelope" system is emphasized.

This publication is intended for larger projects, however, it may be useful for the community planning team.

Website: www.cebc.org

Suite 514 - 409 Granville Street
Vancouver, BC V6C 1T2
Tel: (604) 687-2811
Fax: (604) 688-7110

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STEP TWO:
Defining the Well Protection Area

Ian Rutherford (the Valley District Engineer) and three water purveyors were responsible for defining the well protection area.

Pumphandle Aquifer

Information on the hydrogeology and groundwater conditions in the Pumphandle Valley came from:

- pumping records of the three community wells from the purveyors;
- pumping test reports for Blackwater and Charlie's Wells;
- historic water chemistry for the community wells from the Ministry of Health's WSACS[11] database;
- well records from the Ministry of Environment, Lands and Parks' water well database (WELL);
- 1:20,000 aquifer classification map from the Ministry of Environment, Lands and Parks;
- 1:50,000 Geological Survey of Canada surficial geology map;
- 1:10,000 air photographs; and
- groundwater reports covering the Pumphandle area.

In the fall of 1998, the purveyors hired a consulting hydrogeologist, Henrique Darcy, P. Geo., Hydro-Logic Groundwater Consultants, to compile the groundwater information and delineate the well capture zones.

The well records, surficial geology map, air photos, and reports suggest that there are terraced sand and gravel deposits in the valley that are more than 60 m thick in the central part (Figures CS 1.1 and CS 2.1). The lower part is saturated and forms the principle aquifer – the Pumphandle Aquifer – that supplies groundwater to all the wells in the valley, including the three community wells. The aquifer rests above a layer of till of variable thickness which, in turn, rests on bedrock. The till and bedrock are less permeable and form aquitards.

Aquifer boundaries were taken from the Ministry of Environment, Lands and Parks' aquifer classification map, which designates the Pumphandle Aquifer as a moderately developed, moderately vulnerable, II B (12) aquifer.[12] The aquifer is considered moderately vulnerable because it is unconfined, but the water table is fairly deep in most parts of the valley. Near the three community wells, however, the water table is within a few metres of the surface (Figure CS 2.1) and the aquifer is considered highly vulnerable at this location.

The contours of the water table were estimated using water levels from well records. These show that the water table slopes north towards the three community wells and then north-east towards the lake (Figure CS 2.2). It is assumed that groundwater flows the same way. The ambient hydraulic gradient[13] (i) is about 0.1 at the side of the valley and decreases at the bottom of the valley near the three community wells. There is limited data to map the water table contours along the northwest edge of the valley.

The transmissivity of the aquifer near the community wells, based on pumping tests, is about 0.0036 m^2/s.

TABLE CS 2.1 SUMMARY OF PUMPHANDLE COMMUNITY WELLS

WELL	TYPE	DEPTH (m)	DIAMETER (mm)	RATED CAPACITY (L/s)	DRINKING WATER DEMAND (L/s)	NO OF USERS
Aiken	dug	2.4	915	5.10	5.26	500
Blackwater	drilled	30.5	200	22.73	1.05	100
Charlie	drilled	25.6	150	7.58	0.53	50

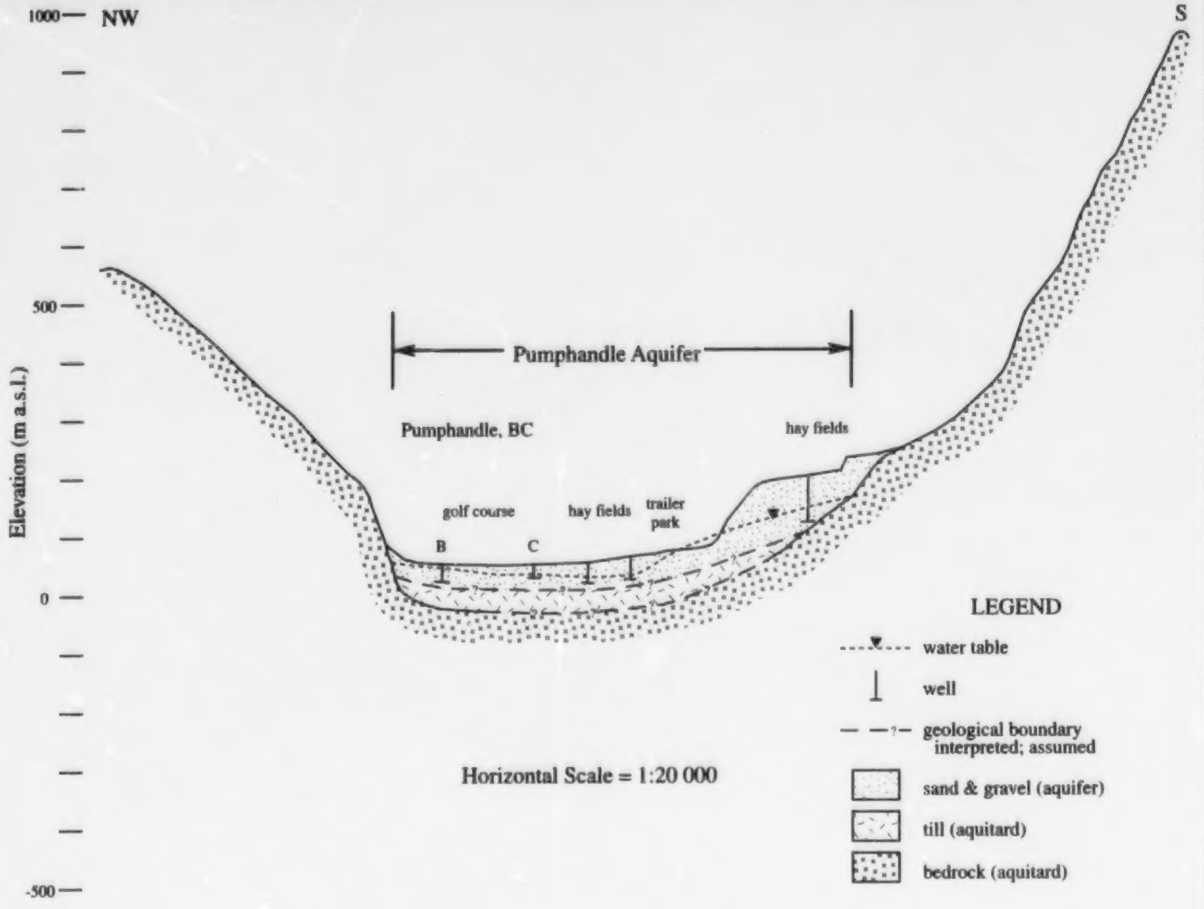
---

[11] Water Sampling Analysis Computer System

[12] For an explanation of the B.C. Aquifer Classification System, see Kreye, R., K. Ronneseth, and M. Wei, 1995. "An Aquifer Classification System for Groundwater Management in British Columbia." In Proceedings, the 6th National Drinking Water Conference, Victoria B.C. pp. 347-358.

[13] The slope of the water table under non-pumping or natural conditions

FIGURE CS 2.1 CROSS-SECTION THROUGH PUMPHANDLE VALLEY


1000
NW
S
500
0
-500
Elevation (m a.s.l.)
Pumphandle Aquifer
Pumphandle, BC
hay fields
golf course
hay fields
trailer park
B
C
LEGEND
water table
well
geological boundary interpreted; assumed
sand & gravel (aquifer)
till (aquitard)
bedrock (aquitard)
Horizontal Scale = 1:20 000

The slope of the water table suggests that recharge to the aquifer comes from precipitation falling on the aquifer and from the mountain-front recharge. Groundwater in the aquifer ultimately discharges to the lake, the local creek and to pumping wells. The lake may also be a localized but significant source of recharge to the community wells during pumping.

A summary of the community wells is shown in Table CS 2.1.

The Capture Zones

The consultant used the maximum pumping rate for each well to determine the individual capture zones for each of the three wells. Capture zones were defined using circular radius methods and analytical equations of groundwater flow. He made a number of assumptions:

- There is no interference between the wells, because of the low pumping rates relative to the transmissivity. The capture zones are therefore calculated separately for each well.
- The neighbouring private wells are used only for domestic purposes, and their effect on the capture zone of the community wells is insignificant.
- Groundwater conditions are in a steady state. This is not strictly true because recharge likely occurs annually. The effect of seasonal fluctuation on delineation of the capture zone areas can not be quantified. However, recent theoretical studies[14] suggest that seasonal effects would probably be insignificant in alluvial aquifer terrains such as the one in Pumphandle and the steady-state assumptions used here are reasonable.

---

[14] Reilly, T. and D. W. Pollock, 1996. "Sources of Water to Wells for Transient Cyclic Systems." Ground Water, Vol. 34, No. 6, pp. 979-988.

In reality, the actual capture zones can not be known with certainty. However, the use of the maximum pumping rates will allow conservative capture zones to be defined. The capture zone delineation method for each well is summarized below and in Table CS 2.2. All three methods were applied to all three wells. The results from each method was reviewed and the most reasonable capture zone was selected for each well.

Aiken's Well is a very shallow well dug into a spring. It supplies the main subdivision in Pumphandle (165 homes – 5.26 L/s requirement) and has a rated capacity of 5.10 L/s. The water requirements exceed the maximum capacity of the shallow well, so it is likely that a new well will need to be drilled to meet future demands.

For Aiken's Well, the results from the fixed radius methods seem the most reasonable. Although a parabolic capture zone was calculated for the Aiken well, the transmissivity used for the calculation was estimated from wells elsewhere in the Pumphandle area. As such, there is a level of uncertainty associated with the capture zone determined using analytical equations. The calculated fixed radius method yields a ten-year radius of 310 m, which is about the size of an arbitrary fixed radius capture zone. However, Aiken's Well is located at the base of a terrace and it is obvious from the topography and water table contours that the flow comes directly from the higher ground to the south. Assuming the water table generally parallels the topography, the capture zone for Aiken's Well was drawn to include an area of about 80 ha uphill to the edge of the aquifer boundary (Figure CS 2.2). The capture zone for the Aiken well is a 300 m radius plus the drainage area upslope from the well.

Blackwater Well supplies 35 homes (1.05 L/s requirements). However, the well is also used for irrigating the golf course and supplies the trailer campground, schools and hotels. In calculating the capture zone area for this well, the maximum pumping capacity was used to account for the heavy irrigation and high seasonal use.

For the Blackwater well, the parabolic capture zone determined using analytical equations seems most reasonable – it is physically based and the transmissivity value used in the calculation was based on the pump test data for that well. Note that the parabolic capture zone is narrow and long, curving west and then south to the edge of the valley side (Figure CS 2.2). The narrow shape of the capture zone means that it is difficult to locate the capture zone without good control on the water table contours.

Charlie's Well supplies a subdivision of 15 homes (current requirements are 0.53 L/s). The well capacity has been rated at about fifteen times that amount (7.58 L/s), based on an initial pumping test conducted to prove up the water supply. The maximum pumping capacity of the well was used to calculate the capture zone, as this would account for any future growth and increased use of water for irrigation. This defines a rather larger capture zone than is currently present.

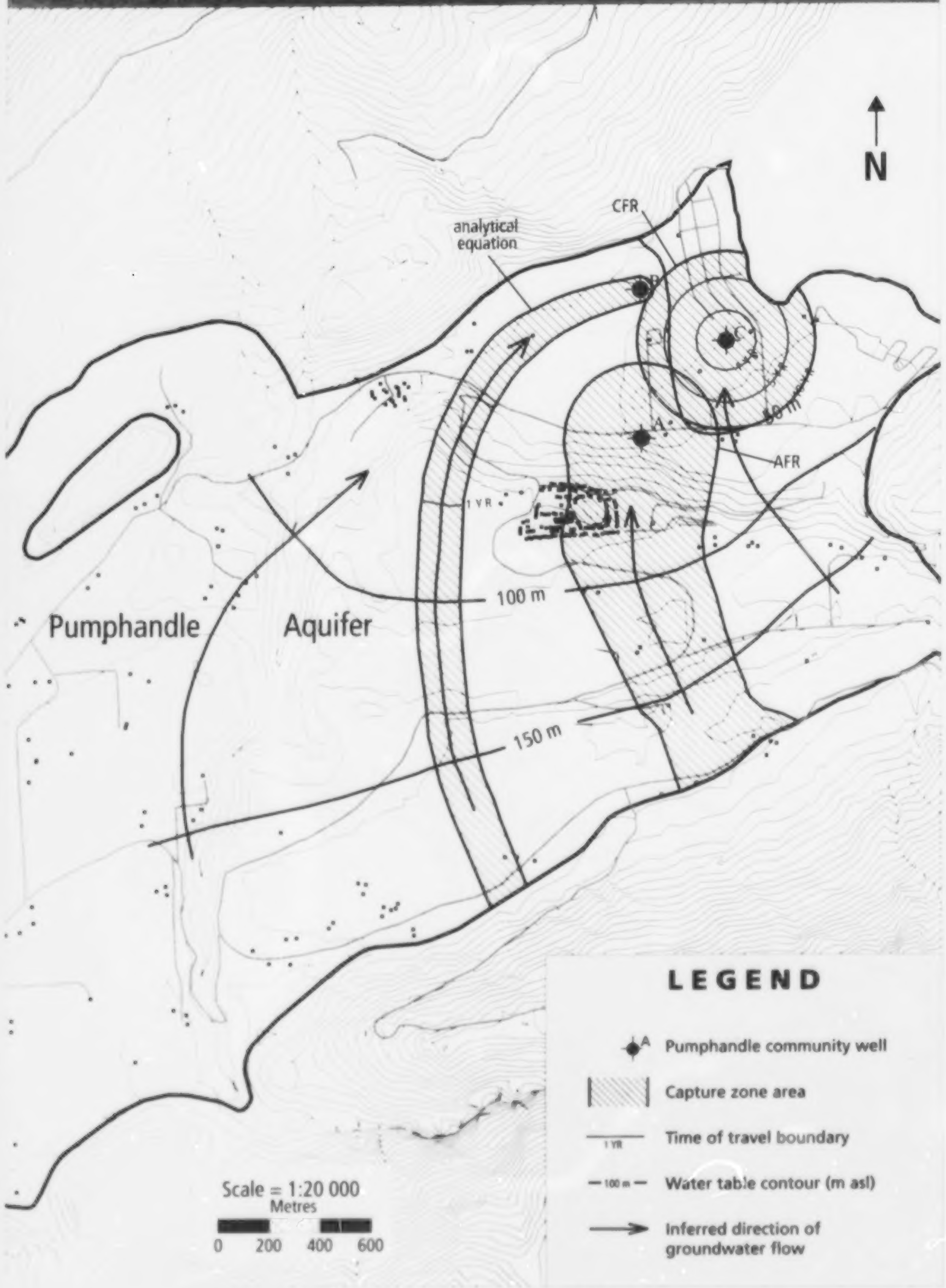
The calculated fixed radius method was used for calculating the capture zone for Charlie's Well. The ten-year calculated fixed radius was calculated as 350 m (38 ha). The calculated fixed radius for the one-year and five-year time of travel was also calculated (Table CS 2.2) and plotted in Figure CS 2.2 for comparison. The maximum pumping capacity of the well was used to calculate the capture zone for Charlie's Well, as this would account for any future

TABLE CS 2.2 SUMMARY OF CAPTURE ZONES FOR THE COMMUNITY WELLS

WELL	Q (L/s)	NO OF USERS	T (m^2/s)	b (m)	i	AFR (m)	CFR r1yr (m)	CFR r5yr (m)	CFR r10yr (m)	ANALYTICAL EQUATIONS Y (m)	ANALYTICAL EQUATIONS X (m)
Aiken	5.10	500	0.0036	21	0.0917	300	99	221	312	8	2
Blackwater	22.73	100	0.0036	17	0.0368	300	232	518	733	86	27
Charlie	7.58	50	0.0036	25	0.0842	300	110	247	349	13	4

Coloured text indicates the most reasonable method for each well.

FIGURE CS 2.2 CAPTURE ZONES FOR COMMUNITY WELLS



growth and increased use of water for irrigation. This results in a rather larger capture zone than is currently present. Analytical equations are not accurate because the water table is relatively flat and the ambient hydraulic gradient can not be determined with any accuracy. It is not clear if the ambient flow near Charlie's Well comes from the southeast or from the west-south-west. To determine this, nearby monitoring wells would be needed to provide groundwater level data to map the flow in more detail.

The Well Protection Areas

Ian Rutherford and Henrique Darcy (the hydrogeologist) defined the well protection area to include the three capture zones (164 ha). In addition, they included the strip of land between the capture zones for Aiken's and Blackwater Wells. This accounted for the uncertainty of location of the actual capture zone for Blackwater Well and the fact that this strip of land may also be a recharge area for Charlie's Well.

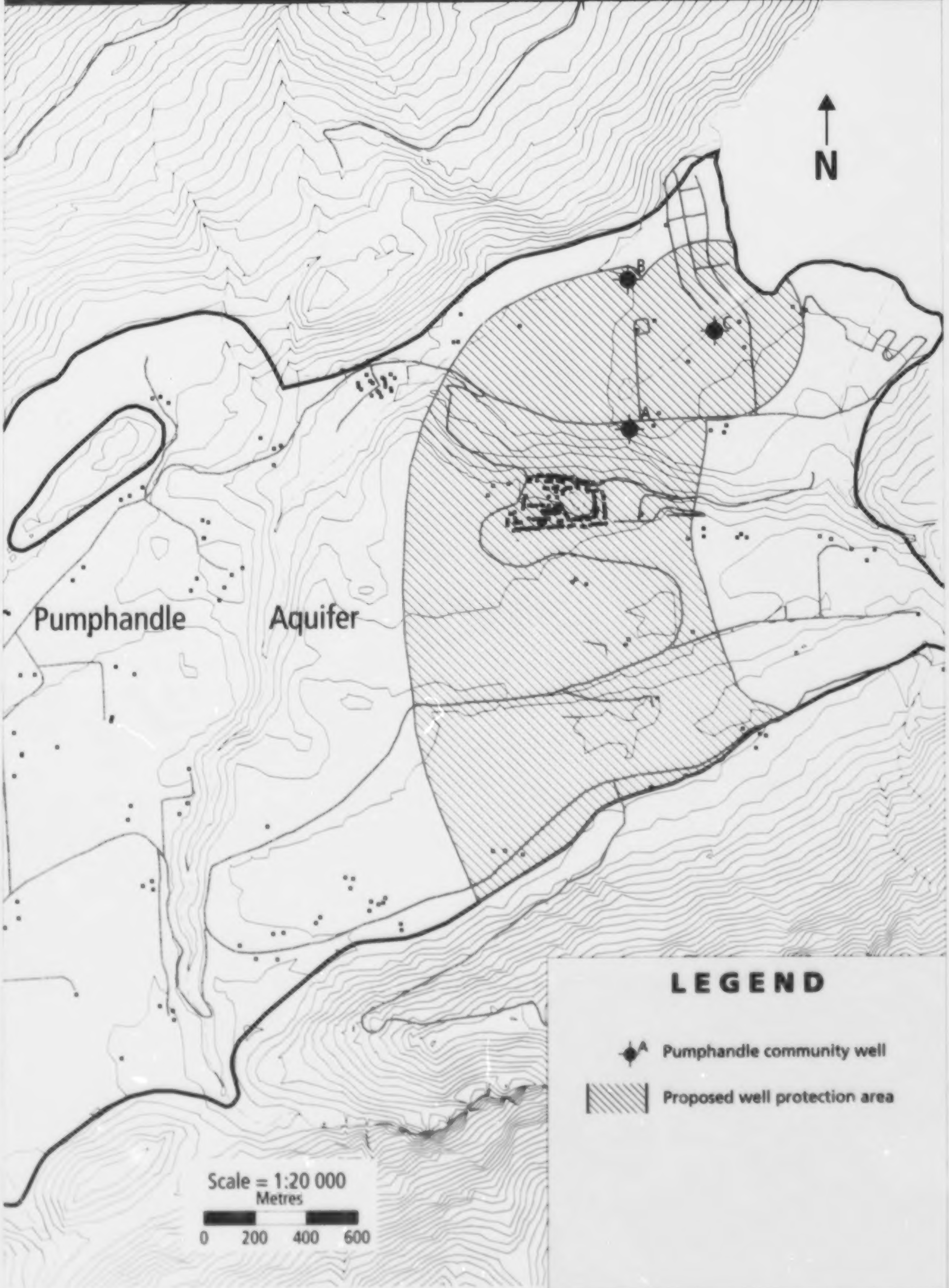
Although including the strip of land increases the total protection area to 261 ha, the total size of the well protection area is still reasonably small, and it does not add greatly to the required protection measures. The preliminary protection area, where land use activities will be documented and protection efforts started, is shown in Figure CS 2.3.

All three capture zones are assumed to end at the aquifer boundaries. Although runoff from the bedrock slope south of Pumphandle (outside of the aquifer boundary) likely recharges the aquifer and the capture zones for Aiken's and Blackwater Wells, it is not considered part of the capture zone or well protection area. However, improper land use activities in this area may indirectly affect the groundwater quality.

Similarly, the lake is not part of the aquifer or the protection area for the community wells, yet a contaminant spill near the lakeshore could impact the water quality of the groundwater in the local area. Lake water may contribute to the recharge of the well and contamination could travel from the lake to the pumping wells.

Finally, the area of aquifer to the southeast of the wells might provide recharge to Charlie's Well, but it has not been included in the preliminary well protection area. Monitoring wells need to be installed around Charlie's Well to provide more detailed groundwater level information. This would indicate whether the recharge area lies to the southeast or to the west as presently assumed.

FIGURE CS 2.3 PROPOSED WELL PROTECTION AREA


N
B
C
A
Pumphandle
Aquifer
LEGEND
Pumphandle community well
Proposed well protection area
Scale = 1:20 000
Metres
0
200
400
600

Step Three

IDENTIFY POTENTIAL CONTAMINANTS

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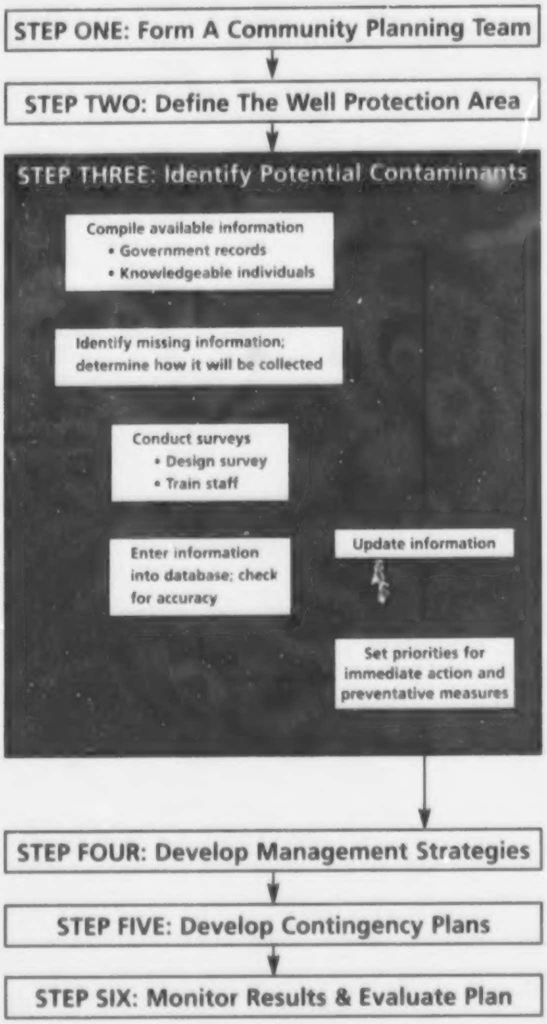
STEP ONE: Form A Community Planning Team
STEP TWO: Define The Well Protection Area
STEP THREE: Identify Potential Contaminants
Compile available information
• Government records
• Knowledgeable individuals
Identify missing information; determine how it will be collected
Conduct surveys
• Design survey
• Train staff
Enter information into database; check for accuracy
Update information
Set priorities for immediate action and preventative measures
STEP FOUR: Develop Management Strategies
STEP FIVE: Develop Contingency Plans
STEP SIX: Monitor Results & Evaluate Plan

More than 750,000 British Columbians rely on groundwater as their source of drinking water, and there are thousands of community well systems in British Columbia. A well protection plan allows communities to identify land use activities that may threaten the quality of their well water, and to develop a strategy to avoid or minimize these threats.

There are six steps to follow in developing a well protection plan:

1. Form a community planning team
2. Define the well protection area
3. Identify potential contaminants
4. Develop and implement management strategies
5. Develop contingency plans
6. Monitor results and evaluate the plan

These steps are described in the six booklets that make up the *Well Protection Toolkit*. Each booklet describes activities that lead to the development and implementation of a well protection plan. In each step, a fictional case study of the town of Pumphandle shows how one community took on this challenge.

Step Three: Identify Potential Contaminants

The third step is to find out what **sources** of potential contaminants are found within the well protection area, **where** they are located and what **type** of contaminants they are. Some of this information can be found using existing files and documents and by talking to knowledgeable individuals. Where information is not easily available, surveys may be needed to collect the missing data.

This data will need to be recorded and organized using some form of database. Once this is done, the resulting information can be used to identify which contaminants and their sources are the greatest and most immediate threat to the water supply. The data and the information will need to be reviewed and updated from time to time.

Figure 3.1 shows the stages of Step Three.

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Identify Potential Contaminants

OBJECTIVES

- To obtain information about past, present and potential sources of contamination
- To document current management practices for activities in the well protection area
- To record this information in a format that can be easily viewed and used
- To set priorities for implementing protection measures
- To update the inventory of potential contaminants on a regular basis

3.1 Compile Available Information

Once you have defined the well protection area (Step Two), the next task is to locate and identify all the potential sources of contamination in this area. It may be necessary to undertake a "reconnaissance-level" inventory, to understand what types of contaminants may be in the capture zone. A great deal of information can be obtained from existing sources, such as zoning and land use maps.

Contaminant sources are often described according to three main categories:

- *Point sources* are those that release contaminants from a specific, known location, such as underground storage tanks, abandoned wells, small commercial/industrial facilities and landfills.
- *Non-point sources* are more extensive in area and diffuse in nature, making it difficult to trace contaminants back to their point of origin. Application of pesticides and fertilizers in gardens and farms,[1] septic systems, storm drains carrying urban runoff, and atmospheric deposition are all potential non-point contaminant sources.
- *Line sources* generally follow a line or corridor, and include sewer lines, gas/petroleum pipelines, and highways (especially those used for transporting dangerous goods). Contamination may occur anywhere along the line source, for example, hydro power-line corridors may use pesticides to control weeds.

The inventory will need to identify the **type of source**, **location** and **nature** of potential contaminants at each site. Non-point and underground sources are harder to identify but must also be included to get a complete picture of the possible threats to the water supply.

Appendix 3.1 is a list of some potential contaminant sources, which can be used as a checklist when setting up your inventory. It includes a list of the potentially harmful components from common household products, which could pollute the groundwater if they are not used according to the label instructions, or are disposed of improperly. This is one area where

WORTH ITS SALT?

In a small community north of Kamloops, B.C., a stockpile of road salt contaminated the groundwater supply.

The cost of responding to contamination was more than two million dollars. Costs included drilling replacement wells, buying property for the new well sites, cleaning contaminated soils, paying damage claims, conducting groundwater studies, replacing corroded pipes, supplying bottled water, holding public meetings, legal fees, and relocating and containing the salt pile. Settling claims alone cost more than $500,000.

A well protection plan would have identified the salt pile as a potential contaminant source. Constructing a suitable storage facility at a cost of about $250,000 could have prevented the incident.

---

[1] Pesticides and fertilizers are of concern when their use is excessive. There may also be a concern depending on what time of year they are applied.

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community education can help to reduce the number of potential contaminants.

In general, groundwater contamination stems from:

- *misuse and improper disposal* of liquid and solid wastes;
- *illegal dumping or abandonment* of household, commercial, or industrial chemicals;
- *accidental spilling* of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; or
- *improper siting, design, construction, operation, or maintenance* of agricultural, residential, municipal (liquid and solid waste), commercial, and industrial facilities.

Contaminants also can stem from atmospheric pollutants, such as airborne sulfur and nitrogen compounds, which are created by smoke, stack emissions, aerosols, and automobile emissions, fall as acid rain, and percolate through the soil. When the sources listed in Table 3.1 are used and managed properly, groundwater contamination is not likely to occur.

Contaminants can reach groundwater from activities occurring on the land surface, such as industrial waste storage; from sources below the land surface but above the water table, such as septic systems; from structures beneath the water table, such as wells; or from contaminated recharge water.

The list of potential contaminants in the capture zone will be very specific to the activities in the area. If your time and financial resources are limited, start by collecting data on activities that are more likely to contaminate your groundwater. For example, data on animal manure stockpiles and septic tanks are much more important than data on the use of antifreeze and car washing detergents, particularly if there are high nitrate levels in the drinking water.

Check Existing Information Sources

It is easiest to start compiling the inventory by checking for data that has already been collected (see sidebar).

SOURCE OF INFORMATION	LOCATION OF INFORMATION
Recent and historical aerial photographs	Maps BC
Telephone directories	Telephone companies
Business licences	Municipal or regional government
Federal, provincial and local government lists dealing with commercial permits	Federal and provincial government
Zoning regulations and zoning maps	Municipal or regional government
Information on domestic water systems and adjacent community wells	Regional Health Authority
Construction permits	Municipal or regional government
MELP[2] contaminated sites and waste databases	Regional MELP office
Real estate title searches	Municipal or regional government, land titles office
Pumptest or well driller reports	Pumptest or well driller, MELP
Location of septic systems	Regional Health Authority
Density of septic systems	Municipal or regional government, Regional Health Authority
Gas pipelines	Municipal or regional government, utility companies
Agricultural land use	Ministry of Agriculture, B.C. Federation of Agriculture, Municipal or regional government
Sewer lines	Municipal or regional government

Government Databases

Federal, provincial and local governments[3] maintain a variety of databases on businesses and other activities that require a permit to operate, and on contaminated sites. These range from computerized systems to papers in file drawers. For example, the Ministry of Environment, Lands and Parks maintains databases on permitted waste discharges (WASTE), contaminated sites (SITE), and accidental spills.[4] The information from these databases may help to identify the activity as a potential contaminant source.

---

[2] Ministry of Environment, Lands and Parks

[3] "Local government" includes regional districts and municipalities

[4] A nominal fee is charged for most database searches

TABLE 3.1 SOURCES OF CONTAMINATION

Source activities	Sources and Quantity of Potential Contaminants	Chemical Category
INDUSTRIAL	**MAJOR:** Chemical manufacturing, electronics, petroleum refining and storage, metal treating, food processing, wood and pulp processing, textile manufacturing.	Organic solvents, petroleum, other organics, metals
	MODERATE/SMALL: Gravel pits.	
COMMERCIAL	**MAJOR:** Gas stations, furniture strippers, drum cleaning.	Petroleum, organics
	MODERATE: Dry cleaners, junk yards, auto repair and body shops, pest control companies, photographic processing, machine shops, auto part stores, lawn and garden/farm stores, paint stores, hardware stores, medical facilities.	Organic solvents, petroleum, pesticides, metals, nitrates, other organics
	SMALL: Grocery stores, department stores, office buildings, laundromats, food service, shoe repair, barber and beauty shop.	Organics, petroleum
AGRICULTURAL	**MODERATE:** Heavy chemical use agriculture (fruits and vegetables), abandoned wells, manure storage (lagoons, stockpiles).	Nitrates, pesticides pathogens, chloride
	SMALL: Low chemical use agriculture (forage crops).	Nitrates
RESIDENTIAL	**MODERATE:** Urban housing, high density (>5 dwelling units per hectare) using septic systems, trailer parks, abandoned wells, sewer mains.	Nitrates, pesticides, petroleum, other organics, pathogens
	SMALL: Moderate and low density (<5 dwelling units per hectare) using septic systems.	Nitrates, pesticides, petroleum, other organics, pathogens
TRANSPORTATION CORRIDORS	**MAJOR TO SMALL:** Highways, roads, underground pipelines.	Spill events, fuel, road salt

Source: adapted from *Groundwater Supply Source Protection, A Guide for Localities in Upstate New York* (1994). Prepared by the Schenectady County Planning Department in cooperation with the Capital Regional Planning Commission and the New York State Department of the Environment Cooperative.

The listings from these databases only identify those activities that require a permit to operate. Business licences, field surveys, zoning maps and air photos should be used to identify potential contaminant activities or sources that do not require a permit. Other inventory approaches such as interviews, site inspections or a review of monitoring data might be necessary to confirm that documented sources still exist.

Zoning Maps

Local governments create zones (industrial, residential, commercial etc.) for different land use within a community. Zoning maps may help the search for potential contaminants, as you can identify potential sources associated with specific land uses (see Table 3.1). Zoning maps can be used to set priorities for investigating each area, by identifying some parts of the community that will need a more thorough investigation.

Aerial Photographs

Aerial photographs can be useful for surveying large areas to identify sites where follow-up investigations will be required. They can also identify potential contaminant sources on private lands where the owners do not permit access.

Interpretations from aerial photographs should always be followed by an on-site inspection. Certain practices, such as storing pesticides in the well pumphouse and over-fertilizing fields or gardens, can only be identified through ground inspections and interviews with landowners.

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Information on domestic septic systems and adjacent community wells	Regional Health Authority
Construction permits	Municipal or regional government
MELP[2] contaminated sites and waste databases	Regional MELP offices
Real estate title searches	Municipal or regional government, land titles office
Purveyor or well driller reports	Purveyor or well drillers, MELP
Location of septic systems	Regional Health Authority
Density of septic systems	Municipal or regional government, Regional Health Authority
Gas pipelines	Municipal or regional government, utility companies
Agricultural Land Use	Ministry of Agriculture; B.C. Federation of Agriculture, municipal or regional governments
Sewer lines	Municipal or regional government

Government Databases

Federal, provincial and local governments[3] maintain a variety of databases on businesses and other activities that require a permit to operate, and on contaminated sites. These range from computerized systems to papers in file drawers. For example, the Ministry of Environment, Lands and Parks maintains databases on permitted waste discharges (WASTE), contaminated sites (SITE), and accidental spills.[4] The information from these databases may help to identify the activity as a potential contaminant source.

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[2] Ministry of Environment, Lands and Parks

[3] "Local government" includes regional districts and municipalities

[4] A nominal fee is charged for most database searches

TABLE 3.1 SOURCES OF CONTAMINATION

Source activities	Sources and Quantity of Potential Contaminants	Chemical Category
INDUSTRIAL	**MAJOR:** Chemical manufacturing, electronics, petroleum refining and storage, metal treating, food processing, wood and pulp processing, textile manufacturing.	Organic solvents, petroleum, other organics, metals
	MODERATE/SMALL: Gravel pits.	
COMMERCIAL	**MAJOR:** Gas stations, furniture strippers, drum cleaning.	Petroleum, organics
	MODERATE: Dry cleaners, junk yards auto repair and body shops, pest control companies, photographic processing, machine shops, auto part stores, lawn and garden/farm stores, paint stores, hardware stores, medical facilities.	Organic solvents, petroleum, pesticides, metals, nitrates, other organics
	SMALL: Grocery stores, department stores, office buildings, laundromats, food service, shoe repair, barber and beauty shop.	Organics, petroleum
AGRICULTURAL	**MODERATE:** Heavy chemical use agricultural (fruits and vegetables), abandoned wells, manure storage (lagoons, stockpiles).	Nitrates, pesticides pathogens, chloride
	SMALL: Low chemical use agriculture (forage crops).	Nitrates
RESIDENTIAL	**MODERATE:** Urban housing, high density (>5 dwelling units per hectare) using septic systems, trailer parks, abandoned wells, sewer mains.	Nitrates, pesticides, petroleum, other organics, pathogens
	SMALL: Moderate and low density (<5 dwelling units per hectare) using septic systems.	Nitrates, pesticides, petroleum, other organics, pathogens
TRANSPORTATION CORRIDORS	**MAJOR TO SMALL:** Highways, roads, underground pipelines.	Spill events, fuel, road salt

Source: adapted from *Groundwater Supply Source Protection, A Guide for Localities in Upstate New York* (1994). Prepared by the Schenectady County Planning Department in cooperation with the Capital Regional Planning Commission and the New York State Department of the Environment Cooperative.

The listings from these databases only identify those activities that require a permit to operate. Business licences, field surveys, zoning maps and air photos should be used to identify potential contaminant activities or sources that do not require a permit. Other inventory approaches such as interviews, site inspections or a review of monitoring data might be necessary to confirm that documented sources still exist.

Zoning Maps

Local governments create zones (industrial, residential, commercial etc.) for different land use within a community. Zoning maps may help the search for potential contaminants, as you can identify potential sources associated with specific land uses (see Table 3.1). Zoning maps can be used to set priorities for investigating each area, by identifying some parts of the community that will need a more thorough investigation.

Aerial Photographs

Aerial photographs can be useful for surveying large areas to identify sites where follow-up investigations will be required. They can also identify potential contaminant sources on private lands where the owners do not permit access.

Interpretations from aerial photographs should always be followed by an on-site inspection. Certain practices, such as storing pesticides in the well pumphouse and over-fertilizing fields or gardens, can only be identified through ground inspections and interviews with landowners.

Historical Data

It is easier to identify contamination from present-day activities than it is to locate long-forgotten sources such as abandoned wells and old waste disposal sites. However, some of these sources still have the potential to contaminate the water supply. Include past land use practices when preparing the inventory:

- Interview long time residents of the area who can provide valuable historical information. Check this anecdotal evidence, where possible, using old air photos and government records;
- Look at maps and other documentation on past human activity. Old zoning maps, local registries of commercial and industrial activities, and property transfer records, titles and deeds may provide clues;
- Compare historical aerial photographs with more recent air photos. These "before and after" comparisons give an historical perspective of the changes in land use and can reveal the location of past sources or activities.

3.2 Conduct Surveys

Once you have assembled all the available data, decide what additional information is needed and how it will be collected. Surveys are also used to identify non-point sources, unregulated sources and previously unknown sources.

Local government staff such as tax assessors, property assessors or health unit workers who have a good working knowledge of the area can help to focus survey efforts, for example by suggesting critical sites for field surveys.

Survey Methods

Some advantages and disadvantages of the various survey methods are shown in Table 3.2.

Personal Interviews

Personal interviews are a valuable way to find out about sources of potential contamination. This can be a "jumping-off point" for information gathering, as these interviews can bring forward information that will help the planning team set priorities for other information gathering activities.

Local officials can often supply names of appropriate contacts. Contacts may include long-term residents, operators or staff with a wealth of knowledge about present and past operations and practices. Personal interviews with key individuals, such as a facility operator, often provide information that may not be available from other sources.

Results from the survey can direct you to other community members who have valuable information. You may then need to conduct a second round of personal interviews.

Mail and Phone Surveys

Mail and phone surveys are a good way to contact a large number of residents and businesses at a relatively low cost. Mailing lists can be obtained from a number of sources such as:

- Property owner names from the tax assessment authority;
- Voter registration lists;
- Chamber of Commerce rosters;
- Utility records; and
- Phone directories.

Once the mail surveys are completed, they must be collected and the results summarized. The collection effort may be as simple as enclosing a self-addressed stamped envelope with a mailed survey, or as labour intensive as a door-to-door collection. For telephone surveys, information is collected by filling out survey sheets during the interviews.

Windshield Survey

A windshield survey is used when more information is needed about potential or existing sources of contamination, and maps or aerial photographs do not provide enough information. A windshield survey requires a vehicle and one or two people, who drive through the area taking notes. A two-person survey is better, so that one can drive while the other takes down the information. This information is later added to the database.

Windshield surveys work well in most communities and may provide a large amount of useful information. They work best in areas where most of

TABLE 3.2 ADVANTAGES AND DISADVANTAGES OF DIFFERENT TYPES OF SURVEY

Type of Survey	Advantages	Disadvantages
PERSONAL INTERVIEWS	Obtain useful information and insight not available from any other source Efficient	Potential for response bias
MAIL SURVEY	Low cost to contact a large number of people Low time requirements Promotes public awareness & participation	Usually a low response rate Variable quality of response Potential for bias
PHONE SURVEY	Low cost to contact a large number of people Respondents are a "captive audience" – response rates higher Can be used selectively to fill in the gaps from mail survey Promotes public awareness & participation	May be a significant labour and time requirement (costs may be reduced by using volunteers) Potential for response bias
WINDSHIELD SURVEY	Require less time for survey staff Effective in identifying obvious potential sources covering a large area Effective in screening sites for future investigation Access is not a problem Direct observations	Not easy to conduct in rough or forested terrain, where sources are not visible from road No personal contact
DOOR-TO-DOOR SURVEY	Increased accuracy and uniformity of the data collected Increased likelihood of identifying previously unknown sources More public interaction Direct observations	Recruiting and training workers can be costly and labour intensive Time consuming
FIELD INSPECTIONS	Good for small areas with easy access Most accurate survey method More public interaction Direct observations	Costly and labour intensive in large areas Need to get owner approval

the sources can be seen from the road, but may be less effective in forested or mountainous areas where many sources are not visible from the road.

Door-to-Door Surveys

Door-to-door surveys involve canvassing the residences and businesses within the well protection area to identify the activities and materials that may pose a hazard to the water supply. This method allows for first-hand observations, which mail and phone surveys do not.

When survey staff are properly trained, the answers to the door-to-door survey will be more concise, complete and uniform than those of mailed surveys.

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When survey staff are properly trained, the answers to the door-to-door survey will be more concise, complete and uniform than those of mailed surveys.

This type of survey can gather a wide range of detailed information and should be tailored for the potential contamination sources expected in the survey area.

Door-to-door surveys should not be conducted during holiday periods. And if survey staff are volunteers, avoid sending them out in bad weather!

Field Inspections

Field inspections consist of an extensive walking survey of an area, and may be used to provide a detailed inspection of specific land uses. Field inspections allow survey staff to look at the area firsthand, without relying on landowners to identify and provide information about sources. It is also an opportunity to see actual management practices and confirm potential sources identified from other survey techniques.

Select an Appropriate Survey Method

The choice of survey method will depend on:

- **The nature of human activities in the well protection area**

  What type of activity are you trying to document? How much detail do you require? For instance, assessing a farm might require an interview with the farmer. For a gas station, a site inspection might be appropriate, while for a trailer park a door-to-door or mail survey might be used.

- **Availability and skills of labour force**

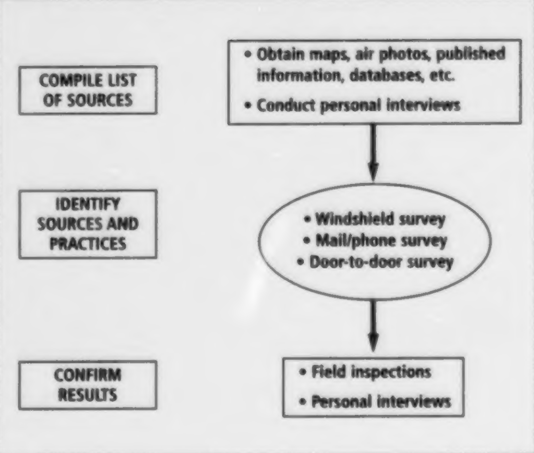
  How many people will you need to conduct the surveys? Who will do the work? If you can't afford to hire labour, look at options such as using students or other volunteers. Who will train the survey staff?

- **Cost**

  Cost may influence your choice of survey technique. Do you need the level of detail provided by a field inspection, or would a phone survey be sufficient?

Conduct the most complete inventory possible. This may involve conducting more than one type of survey, for example mail, phone surveys or personal interviews in conjunction with historic records, door-to-door surveys or field inspections. Figure 3.2 illustrates the steps involved in conducting a survey.

Figure 3.2 Selecting A Survey Method



Find and Train Survey Staff

Finding skilled labour at low cost can be difficult, but there are many options available:

- Local service organizations or citizens' groups may be willing to volunteer their efforts;
- Senior citizens who have observed the development of their community over a number of years can bring a valuable historical perspective;
- High school students could assist with the inventory as part of a school science project;
- Local government staff or consultants may be able to help with training;
- Retired professionals such as engineers or others with technical backgrounds have the expertise needed to identify sources and conduct the survey, and they bring the added advantage of their own knowledge of the area.

Members of the public will likely ask many questions during the survey. Survey staff should be able to provide accurate information and raise people's awareness about the well protection efforts in the community. Make sure that survey staff have good communication skills and solid understanding of both the well protection planning process and the survey itself. Someone with experience in conducting surveys should provide training for volunteers.

Survey staff will need detailed maps of the survey area, lists of "hot-spots" (potential sources of contamination for more in-depth examination), and survey forms to be completed. Develop a numbering system so that survey staff can assign each source a unique identification number. (For example: "1" for the gas station with the leaky tank at Fourth and Elm; "2" for the potato field on Lot 4, DL78.)

To avoid problems with access and liability, get permission for access to the study area from the property owners or operators before going on-site. Survey staff should wear nametags identifying their affiliation with the community planning team.

Work with the Media

If you need the public's help in gathering information (e.g. phone, mail, or door-to-door surveys) it is a good idea to make people aware of the survey and its purpose in advance. Work with the media (radio, community television, and newspapers) to inform the public about the survey process, and conduct the survey once people know about it.

Design and Conduct the Survey

Decide how you will record and use the information gathered (see Section 3.3) before designing and conducting surveys, as this will influence the level of detail and types of information to be collected.

Table 3.3 shows the types of information that could be gathered through the survey. The type of information included will vary with the choice of survey method and the level of information required. It is important to record all the different potential contaminant sources at a given site. For example, a service station may have an underground storage tank and an abandoned well, in addition to an on-site septic system – and all are of potential concern.

Develop a form for survey staff to complete, and make sure they understand all the information that it requires. It is essential to "field test" the survey at a few sites, and then re-evaluate whether all the necessary information is being collected.

3.3 Record and Store Information

The inventory will generate a considerable amount of data that needs to be organized and stored properly, for example in some form of database. The database allows the planning team to analyze the data to show relationships and patterns.

There are many ways to record the data, from simple paper records and maps to complex computerized systems. Will you be gathering a large amount of information? Perhaps a computerized database would be better. Are hand-drawn overlay maps sufficient for your needs? This will avoid the expense of a Geographic Information System (GIS) format.

Remember that evaluating the various protection measures (Step Six) will also generate a great deal of data. Select a data management system that can store and process the data collected in both Steps Three and Six.

Land uses in the well protection area should be mapped. Detailed maps allow the planning team to see the number, location, nature and distribution of potential contaminant sources that exist in the well protection area, and their relationship to other information such as the vulnerable and non-vulnerable areas of the aquifer, the flow direction and the time of travel sub-areas.

Check for Data Accuracy

The information should be accurate, or it will not be as useful or defensible. Use Quality Assurance/Quality Control (QA/QC) measures during the survey and while entering data into the database. This could include training for survey staff, random checks during data collection, and doing cross-references when information on a site comes from more than one survey method.

Develop the Database

Databases can be in a manual, computerized or GIS format. The advantages and disadvantages of manual and other database systems are shown in Table 3.4.

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TABLE 3.3 SURVEY INFORMATION

Type of Information	Categories	Comments
SITE	Unique identifier (e.g. site 001) Location (UTM coordinates) Street address Legal property description	Also plot or identify on base map
LANDOWNER	Site Name Address Phone number Contact information (name, address, phone) for renters or lease holders	May need to keep confidential
LAND USE	Types of activity (e.g. farm, gas station)	A land use classification system helps standardize land use descriptions[5]
SITE CHARACTERISTICS	Distance and direction to well Location within well protection area (e.g. "within one-year TOT," "aquifer highly vulnerable at this point")	
SOURCES OF POTENTIAL CONTAMINANTS	Description Chemicals (type and quantity), chemical composition Status (active or inactive)	Spatial distribution of chemical use and disposal practices
HISTORY	Any previous discharges	
SPILL RESPONSE EQUIPMENT	Describe existing management practices & containment systems List equipment/materials for spills	Written emergency response plan
SURVEY STAFF	Name and phone number Date of visit	
PHOTOGRAPHS	List and attach	
COMMENTS	Concerns, e.g. improper storage of chemicals, improper irrigation practices, and areas that could not be checked	

Manual Systems

Before the age of the computer, most data were managed through manual filing systems. Data sheets, index cards, maps and aerial photographs were stored in file folders and filing cabinets.

In a manual filing system, data records are generally organized according to some specific criteria, such as land use categories or by geographic areas. For a given category of land use activity, it is then easy to find all land parcels that are associated with that category.

A manual inventory system based on papers, files and paper maps may be perfectly adequate for a small well protection area with limited land use activities. Data collected from the surveys can be

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[5] Example: Sawicki, J. and G. Runka, 1986. *Land Use Classification in British Columbia.* Manual 8, Ministry of Agriculture and Food and Ministry of Environment. 31pp.

TABLE 3.4 ADVANTAGES AND DISADVANTAGES OF DIFFERENT DATABASE SYSTEMS

Type of Database System	Advantages	Disadvantages
MANUAL SYSTEMS	Adequate for a limited amount of data Inexpensive to set up No special equipment or training	Inflexible Hard to deal with large amounts of files Hard to do complicated data retrievals Information cannot be easily shared by other programs High degree of redundancy depending on how the system is indexed Very limited data analysis and processing capabilities Labour intensive to maintain Difficult to update and backup
COMPUTERIZED DATABASE MANAGEMENT SYSTEMS	Greater flexibility Less restricted data usage Centralized control of data ensures integrity of database Easy to conduct unique database searches Less data redundancy Increased control and data security and accessibility	Costs of hardware and software acquisition and maintenance Additional training of users Risk of losing or corrupting the data due to insufficient backup and recovery procedures Set up requires technical assistance and can be expensive Risk of untrained user affecting the integrity of the database
GEOGRAPHIC INFORMATION SYSTEMS (GIS)	Extremely useful tool Easy to scan areas for potential sources of contamination Useful for managing and organizing information from a variety of sources GIS can be shared with other programs Effective spatial data query and analysis	Very expensive to implement High level of user training essential

entered on data sheets and organized according to land use categories or parcel identification numbers. Index files should be developed so that it is easy to find information, and to reduce duplication. Make sure you have a system to keep the data and files up to date.

Computerized Database Management Systems

Database Management Systems (DBMS) were developed to manage large quantities of data in an orderly manner, and to perform data analysis. Data from many sources can be combined and presented in reports that are concise and understandable. Typical database programs include Access and FoxPro.

Spreadsheets programs such as Excel can also be useful for decision-making, however they are not as good for analyzing data.

Setting up a DBMS can be complicated and expensive, and a skilled database staff person is needed to set up and maintain the system. However, the long-term benefits of using DBMS technologies

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Spreadsheets programs such as Excel can also be useful for decision-making, however they are not as good for analyzing data.

Setting up a DBMS can be complicated and expensive, and a skilled database staff person is needed to set up and maintain the system. However, the long-term benefits of using DBMS technologies frequently outweigh the costs. These systems provide a much better basis for complex data processing, decision making support and integrating information among different agencies.

Geographic Information Systems

A Geographic Information System (GIS) is a computerized method that records data and shows it on a series of map layers. It is a very effective way to capture, store, update, manipulate, analyze and display all forms of spatial information.[6] This could include water supply wells, water distribution lines, soil/vegetation types, vulnerability of the aquifer, and direction of groundwater flow. It can be linked to a database (such as FoxPro or Access) that contains detailed information about each site.

GIS is a powerful analytical tool, but can be complex and expensive to set up. It is a good option for larger purveyors (such as local governments) that have staff trained in GIS. If the planning team is considering this option, you should speak to a GIS specialist. More information about setting up a GIS is provided in Appendix 3.2.

Maintain the Database

All data management systems require periodic maintenance. The changing nature of land use activities means that the database has to be updated regularly, perhaps repeating the inventory every few years. The data must be securely stored to minimize any chances of accidental destruction or gradual degradation over time. Only authorized individuals should be able to change the information in the database.

You will need to ensure that new users are trained to use the database, and to update the skills of current users whenever modifications are made to the system. Make sure there is a system for backup and recovery of data in case there is an error or malfunction.

3.4 Analyze the Data and Set Priorities

Examine the data to identify the sites and sources of greatest priority for immediate attention. Don't forget to include underground and non-point sources. Consider the following questions when settings priorities:

1. **How vulnerable is the aquifer?**

   Where the aquifer is protected by clay or till layers, surface water and any contaminants are less likely to reach the groundwater supply. Such areas might be given a lower priority for protection measures.

   Where the aquifer is unconfined, it is more vulnerable to contamination by pollutants and should be a higher priority for protection. Standard methods are available to determine the vulnerability of different parts of the aquifer (see Step Two).

2. **How far is the source of potential contamination from the well?**

   Sources closest to the well (e.g. within the one-year time of travel area) should be the highest priority. Where time of travel is not known, distance to well can be used to establish priority (everything else being equal). (See Step Two.)

3. **How great is the potential for contamination?**

   Certain types of operations usually pose a threat to the groundwater. For example, activities that use hazardous materials, sites that are known to be polluting, or sites where poor management practices are used might be considered as having a greater potential to contaminate. A leaky underground storage tank in a gas station would be given greater priority than a gas station with a new double-lined tank.

The consequences of contamination should also be considered: the nature of the contaminant, the volume of contaminant, toxicity, and the risk.

By the end of this process, the planning team will have a list of potential contaminant sources for which management strategies will be developed (Step Four).

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[6] Spatial data is any data that contains information about their geographic location (e.g. a well with geographic coordinates such as latitude and longitude)

This is one possible method for a priority assessment. More complicated methodologies may be required, in which case you may wish to hire a consultant.

3.5 Update Information

Information gathered from the inventory needs to be updated regularly – every six months to two years. The timing depends on how fast the community is growing and changing, and how much water use is increasing.

The inventory should be updated any time there are changes in the community. For example when a new business opens in a well protection area, this information it could be immediately entered into the inventory and the owner provided with information on what it means to be in a well protection area.

CHECKLIST FOR STEP THREE

The following is a basic checklist for action items to be completed during Step Three of the well protection planning process:

ACTION ITEM	COMMENTS	COMPLETED
Decide who is responsible for these activities	Enlist technical and volunteer assistance if required.	☐
Compile available information	Check government records, talk to knowledgeable individuals.	☐
Decide what other information needs to be gathered	Determine appropriate method(s) for collecting this information.	☐
Conduct Surveys	Train staff, think how you will compile and use the information collected.	☐
Enter data into a database	Check for data accuracy.	☐
Review the data and determine the priority	Set priorities for each potential contaminant source.	☐
Update information	Determine how often information will be reviewed.	☐

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Enter data into a database	Check for data accuracy.	☐
Review the data and determine the priority	Set priorities for each potential contaminant source.	☐
Update information	Determine how often information will be reviewed.	☐

Appendix 3.1 Potential Sources of Groundwater Contamination[7]

This list of potential contaminant sources is meant as a reference. The actual list of potential contaminants in the capture zone will be very specific to your area and the activities in the area.

This list is not exhaustive – there may be sources not included. As well, not all sources will be present in your community.

NATURALLY OCCURRING SOURCES	
[illegible]	**Health, Environmental, or Aesthetic contaminant**
[illegible]	Aesthetic Contaminants: iron, iron bacteria, manganese, calcium and magnesium (hardness) Health and Environmental Contaminants: arsenic; asbestos; metals; chlorides; fluorides; sulfates; sulfate-reducing bacteria and other microorganisms
[illegible]	Excessive sodium; bacteria; viruses; low pH (acidic) water
[illegible]	Bacteria, odour, colour, taste
[illegible]	Uranium deposits Radon gas
[illegible]	Salt water or other poor quality water

AGRICULTURAL SOURCES	
[illegible]	**Health, Environmental, or Aesthetic contaminant**
[illegible]	Viruses, bacteria (coliform and non-coliform) and other pathogens Coliform bacteria can indicate the possible presence of pathogenic (disease-causing) microorganisms that may be transmitted in human or animal feces. Diseases such as typhoid fever, hepatitis, diarrhea, and dysentery can result from fecal contamination of water supplies Nitrates; phosphates; chloride; colour, taste and odour Chemical sprays and dips for controlling insect, bacterial, viral, and fungal pests on livestock
[illegible]	Pesticides including herbicides, insecticides, rodenticides, fungicides, and avicides. Many pesticides are highly toxic and quite mobile in the subsurface Fertilizers: The USEPA National Pesticides Survey found that the use of fertilizers correlates to nitrate contamination of groundwater supplies Pesticide and fertilizer residues Gasoline and motor oils from chemical applicators
[illegible]	Pesticides Fertilizers Chemical residues (residuals) Left-over product containers
[illegible]	Automotive wastes: Gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils Welding wastes
[illegible]	Pesticide Fertilizers Bacteria

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[7] This table is adapted from: U.S. Environmental Protection Agency, 1993. *Wellhead Protection: A Guide for Small Communities*. Office of Research and Development, US Environmental Protection Agency, Washington, DC. 144pp; and *Natural Resources Facts: Household Hazardous Wastes*, Fact Sheet No. 88-3, Department of Natural Science, University of Rhode Island, August 1988.

MUNICIPAL SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Schools and government offices and grounds	Solvents, acids; alkalis, residues from cleaning products that may contain chemicals such as xylenes, glycol esters, isopropanol, 1,1,1 trichloroethane, sulfonates, chlorinated phenols and cresols Machinery/vehicle servicing wastes; gasoline and heating oil from storage tanks; waste oils General building wastes Pesticides, herbicides and fertilizers
Parklands, public and residential areas infested with mosquitoes, gypsy moths, ticks, ants, or other pests	Fertilizers Pesticides, herbicides, insecticides
Highways, road maintenance depots, and deicing operations	Automotive waste: gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils Herbicides in highway rights-of-way Road salt (sodium and calcium chloride) and anti-caking additives (ferric ferrocyanide, sodium ferrocyanide) Anti-corrosives (phosphate and chromate)
Municipal sewage treatment plants	Municipal wastewater sludge: may contain organic matter; nitrates; inorganic salts; heavy metals; coliform and non-coliform bacteria; and viruses Wastewater treatment chemicals: may include calcium oxide; alum; activated alum, carbon, and silica; polymers; ion exchange resins; sodium hydroxide; chlorine; ozone; and corrosion inhibitors
Storage, treatment, and disposal of waste from municipal treatment plants	Sewage wastewater; lagoons, and other surface impoundments Nitrates; other liquid wastes; microbiological contaminants
Land areas applied with wastewater	Organic matter; nitrates; inorganic salts; heavy metals; coliform and non-coliform or wastewater byproducts, bacteria; viruses; sludge; non-hazardous wastes
Storm water drains and basins	Urban runoff; gasoline; oil; other petroleum products; road salt; microbiological contaminants
Combined sewer overflows (municipal sewers and storm water drains)	Municipal wastewater sludge and treatment chemicals Urban runoff; gasoline; oil; other petroleum products; road salt Microbiological contaminants
Recycling/reduction facilities	Residential and commercial solid waste residues
Municipal waste landfills	Leachate; organic and inorganic chemical contaminants; wastes from households and businesses; nitrates; oils; metals Biomedical and related waste. For example, in areas where there are hospitals with nuclear medicine departments, soiled diapers from patients undergoing nuclear medicine procedures may be landfilled
Open dumping and burning sites, closed dumps	Organic and inorganic chemicals; metals; oils; wastes from households and businesses
Municipal incinerators	Heavy metals; hydrocarbons; formaldehyde; methane; ethane; ethylene; acetylene; sulfur and nitrogen compounds
Water supply wells, monitoring wells, older wells, domestic and livestock wells, unsealed and abandoned wells, and test hole wells	Surface runoff; effluents from barnyards, feedlots, septic tanks or cesspools; gasoline; used motor oil; road salt; fertilizers and pesticides
Sumps and dry wells	Storm water runoff; spilled liquids; used oil; antifreeze; gasoline; other petroleum products; road salt; pesticides; and a wide variety of other substances
Drainage wells	Pesticides; bacteria
Well pumping that causes inter-aquifer leakage, induced filtration, landward migration of sea water in coastal areas, etc.	Saltwater; excessively mineralized water
Artificial groundwater recharge	Storm water runoff; excess irrigation water; stream flow; cooling water; treated sewage effluent; other substances that may contain contaminants, such as nitrates, metals, detergents, synthetic organic compounds, bacteria, and viruses

Appendix 3.1 Potential Sources of Groundwater Contamination[7]

This list of potential contaminant sources is meant as a reference. The actual list of potential contaminants in the capture zone will be very specific to your area and the activities in the area.

This list is not exhaustive – there may be sources not included. As well, not all sources will be present in your community.

NATURALLY OCCURRING SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Rocks and soils	Aesthetic Contaminants: iron, iron bacteria, manganese, calcium and magnesium (hardness) Health and Environmental Contaminants: arsenic; asbestos; metals; chlorides; fluorides; sulfates; sulfate-reducing bacteria and other microorganisms
Contaminated Water	Excessive sodium; bacteria; viruses; low pH (acidic) water
Decaying organic matter	Bacteria, odour, colour, taste
Geological radioactivity	Uranium deposits Radon gas
Natural hydrogeological events and formations	Salt water or other poor quality water

AGRICULTURAL SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Animal feedlots and burial areas Manure treatment (composting) Manure spreading areas Manure storage areas and lagoons Animal waste disposal areas	Viruses, bacteria (coliform and non-coliform) and other pathogens Coliform bacteria can indicate the possible presence of pathogenic (disease-causing) microorganisms that may be transmitted in human or animal feces. Diseases such as typhoid fever, hepatitis, diarrhea, and dysentery can result from fecal contamination of water supplies Nitrates; phosphates; chloride; colour, taste and odour Chemical sprays and dips for controlling insect, bacterial, viral, and fungal pests on livestock
Crop areas and irrigation sites	Pesticides including herbicides, insecticides, rodenticides, fungicides, and avicides. Many pesticides are highly toxic and quite mobile in the subsurface Fertilizers: The USEPA National Pesticides Survey found that the use of fertilizers correlates to nitrate contamination of groundwater supplies Pesticide and fertilizer residues Gasoline and motor oils from chemical applicators
Chemical storage areas and containers	Pesticides Fertilizers Chemical residues (residuals) Left-over product containers
Farm machinery areas	Automotive wastes: Gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes; engine and metal degreasers; hydraulic (brake) fluid; and motor oils Welding wastes
Agricultural drainage wells	Pesticide Fertilizers Bacteria

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[7] This table is adapted from: U.S. Environmental Protection Agency, 1993. *Wellhead Protection: A Guide for Small Communities*. Office of Research and Development, US Environmental Protection Agency, Washington, DC. 144pp; and *Natural Resources Facts: Household Hazardous Wastes*. Fact Sheet No. 88-3, Department of Natural Science, University of Rhode Island, August 1988.

MUNICIPAL SOURCES*

Source	Health, Environmental, or Aesthetic contaminant
Schools and government offices and grounds	Solvents, acids; alkalis, residues from cleaning products that may contain chemicals such as xylenes, glycol esters, isopropanol, 1,1,1 trichloroethane, sulfonates, chlorinated phenols and cresols Machinery/vehicle servicing wastes; gasoline and heating oil from storage tanks; waste oils General building wastes Pesticides, herbicides and fertilizers
Parklands, public and residential areas infested with mosquitoes, gypsy moths, ticks, ants, or other pests	Fertilizers Pesticides, herbicides, insecticides
Highways, road maintenance depots, and deicing operations	Automotive waste: gasoline; antifreeze; automatic transmission fluid; battery acid; engine and radiator flushes, engine and metal degreasers; hydraulic (brake) fluid; and motor oils Herbicides in highway rights-of-way Road salt (sodium and calcium chloride) and anti-caking additives (ferric ferrocyanide, sodium ferrocyanide) Anti-corrosives (phosphate and chromate)
Municipal sewage treatment plants	Municipal wastewater sludge: may contain organic matter; nitrates; inorganic salts; heavy metals; coliform and non-coliform bacteria; and viruses Wastewater treatment chemicals: may include calcium oxide; alum; activated alum, carbon, and silica; polymers; ion exchange resins; sodium hydroxide; chlorine; ozone; and corrosion inhibitors
Storage, treatment, and disposal of waste from municipal treatment plants	Sewage wastewater; lagoons, and other surface impoundments Nitrates; other liquid wastes; microbiological contaminants
Land areas applied with wastewater	Organic matter; nitrates; inorganic salts; heavy metals; coliform and non-coliform or wastewater byproducts, bacteria; viruses; sludge; non-hazardous wastes
Storm water drains and basins	Urban runoff; gasoline; oil; other petroleum products; road salt; microbiological contaminants
Combined sewer overflows (municipal sewers and storm water drains)	Municipal wastewater sludge and treatment chemicals Urban runoff; gasoline; oil; other petroleum products; road salt Microbiological contaminants
Recycling/reduction facilities	Residential and commercial solid waste residues
Municipal waste landfills	Leachate; organic and inorganic chemical contaminants; wastes from households and businesses; nitrates; oils; metals Biomedical and related waste. For example, in areas where there are hospitals with nuclear medicine departments, soiled diapers from patients undergoing nuclear medicine procedures may be landfilled
Open dumping and burning sites, closed dumps	Organic and inorganic chemicals; metals; oils; wastes from households and businesses
Municipal incinerators	Heavy metals; hydrocarbons; formaldehyde; methane; ethane; ethylene; acetylene; sulfur and nitrogen compounds
Water supply wells, monitoring wells, older wells, domestic and livestock wells, unsealed and abandoned wells, and test hole wells	Surface runoff; effluents from barnyards, feedlots, septic tanks or cesspools; gasoline; used motor oil; road salt; fertilizers and pesticides
Sumps and dry wells	Storm water runoff; spilled liquids; used oil; antifreeze; gasoline; other petroleum products; road salt; pesticides; and a wide variety of other substances
Drainage wells	Pesticides; bacteria
Well pumping that causes inter aquifer leakage, induced filtration, landward migration of sea water in coastal area; etc	Saltwater; excessively mineralized water
Artificial groundwater recharge	Storm water runoff; excess irrigation water; stream flow; cooling water; treated sewage effluent; other substances that may contain contaminants, such as nitrates, metals, detergents, synthetic organic compounds, bacteria, and viruses

COMMERCIAL SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Airports, abandoned airfields	Jet fuels; de-icers; diesel fuel; chlorinated solvents; automotive wastes; heating oil; building wastes
Auto repair shops	Waste oils; solvents; acids; paints; automotive wastes; miscellaneous cutting oils
Barber and beauty shops	Perm solutions; dyes; miscellaneous chemicals contained in hair rinses
Boat yards and marinas	Diesel fuels; oil; septage from boast waste disposal areas; wood preservative and treatment chemicals; paints; waxes; varnishes; automotive wastes
Bowling alleys	Epoxy; urethane-based floor finish
Car dealerships (especially those with service departments)	Automotive wastes, waste oils; solvents; miscellaneous wastes
Car washes	Soaps; detergents; waxes; miscellaneous chemicals
Campgrounds	Septage; gasoline; diesel fuel from boats; pesticides for controlling mosquitoes, ants, ticks, gypsy moths, and other pests; household hazardous wastes from recreational vehicles (RVs)
Carpet stores	Glues and other adhesives; fuel from storage tanks if forklifts are used
Cemeteries	Leachate; lawn and garden maintenance chemicals
Construction trade areas and materials (plumbing, heating and air conditioning, painting, paper hanging, decorating, drywall and plastering, acoustical insulation, carpentry, flooring, roofing and sheet metal, wrecking and demolition, etc.)	Solvents; asbestos; paints; glues and other adhesives; waste tars Insulation; lacquers; sealants; epoxy waste; miscellaneous chemical wastes
Country clubs	Fertilizers; herbicides; pesticides; swimming pool chemicals; automotive wastes
Dry cleaners	Solvents (perchloroethylene, petroleum solvents, Freon) Spotting chemicals (trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate)
Funeral services and crematories	Formaldehyde; wetting agents; fumigants; solvents
Furniture repair and finishing shops	Paints; solvents; degreasing and solvent recovery sludges
Gasoline services stations	Oils; solvents; gasoline; miscellaneous wastes
Golf courses	Fertilizers; herbicides; pesticides for controlling mosquitoes, ticks, ants, and other pests; shop wastes
Hardware/lumber/parts stores	Hazardous chemical products in inventories; heating oil and fork lift fuel from storage tanks; wood-staining and treating products such as creosote
Heating oil companies	Heating oil; wastes from truck maintenance areas, underground storage tanks
Horticultural practices, garden nurseries, florists	Herbicides, insecticides, fungicides, and other pesticides
Jewellery/metal plating shops	Sodium and hydrogen cyanide; metallic salts
Laundromats	Detergents; bleaches; fabric dyes
Medical institutions	X-ray developers and fixers; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; dental acids; miscellaneous chemicals
Office buildings and office complexes	Building wastes; lawn and garden maintenance chemicals; gasoline; motor oil

COMMERCIAL SOURCES continued

Source	Health, Environmental, or Aesthetic contaminant
Paint stores	Paints; paint thinners; lacquers; varnishes; other wood treatments
Pharmacies	Spilled and returned products
Photography shops, photo processing laboratories	Biosludges; silver sludges; cyanides; miscellaneous sludges
Print shops	Solvents; inks; dyes; oils; photographic chemicals
Railroad tracks and yards	Diesel fuel; herbicides for rights-of-way; creosote for preserving wood ties
Research laboratories	X-ray developers and fixers; infectious wastes; radiological wastes, biological wastes, disinfectants, asbestos; beryllium; solvents; infectious materials; drugs; disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); miscellaneous chemicals
Scrap and junk yards	Any wastes from businesses and households; oils
Sports and hobby shops	Gunpowder and ammunition; rocket engine fuel; model aeroplane glue
Storage tanks (above-ground and underground)	Heating oil; diesel fuel; gasoline; other petroleum products; other commercially used chemicals
Transportation services for passenger transit (local and interurban)	Waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil, other automotive wastes
Veterinary services	Solvents; infectious materials; vaccines; drugs; disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); x-ray developers and fixers
X-Ray clinics and devices	X-ray developers and fixers may contain reclaimable silver, glutaldehyde, hydroquinone, phenedone, potassium bromide, sodium sulfite, sodium carbonate, thiosulfates and potassium alum

COMMERCIAL SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Airports, abandoned airfields	Jet fuels; de-icers; diesel fuel; chlorinated solvents; automotive wastes; heating oil; building wastes
Auto repair shops	Waste oils; solvents; acids; paints; automotive wastes; miscellaneous cutting oils
Barber and beauty shops	Perm solutions; dyes; miscellaneous chemicals contained in hair rinses
Boat yards and marinas	Diesel fuels; oil; septage from boast waste disposal areas; wood preservative and treatment chemicals; paints; waxes; varnishes; automotive wastes
Bowling alleys	Epoxy; urethane-based floor finish
Car dealerships (especially those with service departments)	Automotive wastes, waste oils; solvents; miscellaneous wastes
Car washes	Soaps; detergents; waxes; miscellaneous chemicals
Campgrounds	Septage; gasoline; diesel fuel from boats; pesticides for controlling mosquitoes, ants, ticks, gypsy moths, and other pests; household hazardous wastes from recreational vehicles (RVs)
Carpet stores	Glues and other adhesives; fuel from storage tanks if forklifts are used
Cemeteries	Leachate; lawn and garden maintenance chemicals
Construction trade areas and materials (plumbing, heating and air conditioning, painting, paper hanging, decorating, drywall and plastering, acoustical insulation, carpentry, flooring, roofing and sheet metal, wrecking and demolition, etc.)	Solvents; asbestos; paints; glues and other adhesives; waste tars Insulation; lacquers; sealants; epoxy waste; miscellaneous chemical wastes
Country clubs	Fertilizers; herbicides; pesticides; swimming pool chemicals; automotive wastes
Dry cleaners	Solvents (perchloroethylene, petroleum solvents, Freon) Spotting chemicals (trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate)
Funeral services and crematories	Formaldehyde; wetting agents; fumigants; solvents
Furniture repair and finishing shops	Paints; solvents; degreasing and solvent recovery sludges
Gasoline services stations	Oils; solvents; gasoline; miscellaneous wastes
Golf courses	Fertilizers; herbicides; pesticides for controlling mosquitoes, ticks, ants, and other pests; shop wastes
Hardware/lumber/parts stores	Hazardous chemical products in inventories; heating oil and fork lift fuel from storage tanks; wood-staining and treating products such as creosote
Heating oil companies	Heating oil; wastes from truck maintenance areas, underground storage tanks
Horticultural practices, garden nurseries, florists	Herbicides, insecticides, fungicides, and other pesticides
Jewellery/metal plating shops	Sodium and hydrogen cyanide; metallic salts
Laundromats	Detergents; bleaches; fabric dyes
Medical institutions	X-ray developers and fixers; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; dental acids; miscellaneous chemicals
Office buildings and office complexes	Building wastes; lawn and garden maintenance chemicals; gasoline; motor oil

COMMERCIAL SOURCES continued

Source	Health, Environmental, or Aesthetic contaminant
Paint stores	Paints; paint thinners; lacquers; varnishes; other wood treatments
Pharmacies	Spilled and returned products
Photography shops, photo processing laboratories	Biosludges; silver sludges; cyanides; miscellaneous sludges
Print shops	Solvents; inks; dyes; oils; photographic chemicals
Railroad tracks and yards	Diesel fuel; herbicides for rights-of-way; creosote for preserving wood ties
Research laboratories	X-ray developers and fixers; infectious wastes; radiological wastes; biological wastes; disinfectants; asbestos; beryllium; solvents; infectious materials; drugs; disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); miscellaneous chemicals
Scrap and junk yards	Any wastes from businesses and households; oils
Sports and hobby shops	Gunpowder and ammunition; rocket engine fuel; model aeroplane glue
Storage tanks (above-ground and underground)	Heating oil; diesel fuel; gasoline; other petroleum products; other commercially; used chemicals
Transportation services for passenger transit (local and interurban)	Waste oil; solvents; gasoline and diesel fuel from vehicles and storage tanks; fuel oil; other automotive wastes
Veterinary services	Solvents; infectious materials; vaccines; drugs; disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); x-ray developers and fixers
X-Ray clinics and devices	X-ray developers and fixers may contain reclaimable silver, glutaldehyde, hydroquinone, phenedone, potassium bromide, sodium sulfite, sodium carbonate, thiosulfates and potassium alum

INDUSTRIAL SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Material stockpiles (coal, metallic ores, phosphates, gypsum)	Acid drainage; other hazardous and non-hazardous wastes
Waste tailing ponds (commonly for the disposal of mining wastes)	Acids; metals; dissolved solids; radioactive ores; other hazardous and non-hazardous wastes
Transport and transfer stations (Trucking terminals and rail yards	Fuel tanks; repair shop wastes, other hazardous and non-hazardous wastes
Above-ground and underground storage tanks and containers	Heating oil; diesel and gasoline fuel; other petroleum products; hazardous and non-hazardous materials and wastes
Storage, treatment, and disposal ponds, lagoons, and other surface impoundments	Hazardous and non-hazardous liquid wastes; septage; sludge
Chemical landfills	Leachate; hazardous and non-hazardous wastes; nitrates
Radioactive waste disposal materials	Radioactive wastes from medical facilities Radionuclides (uranium, plutonium)
Unsewered wet and dry excavation sites (unregulated dumps)	A wide range of substances; solid and liquid wastes; oil-field brines; spent acids from steel mill operations; snow removal piles containing large amounts of salt
Operating and abandoned production and exploratory wells (for gas, oil, coal, geothermal, and heat recovery); test hole wells; monitoring and excavation wells	Metals; acids; minerals; sulfides; other hazardous and non-hazardous chemicals
Dry wells	Saline water from wells pumped to keep them dry
Injection wells	Highly toxic wastes; hazardous and non-hazardous industrial wastes; oil-field brines
Well drilling operations	Brines associated with oil and gas operations

INDUSTRIAL SOURCES: PRESENTLY OPERATED OR TORN-DOWN FACILITIES

Source	Health, Environmental, or Aesthetic contaminant
Asphalt plants	Petroleum derivatives
Communication equipment	Nitric, hydrochloric, and sulfuric acid wastes; heavy metal sludges
Copper manufacturers	Contaminated etchant (e.g. ammonium persulfate); cutting oil and degreasing solvent (trichloroethane, Freon, or trichloroethylene); waste oils; corrosive soldering flux; paint sludge; waste plating solution
Electric and electronic equipment	Cyanides; metal sludges; caustics (chromic acid); solvents; oils; manufacturers and storage facilities alkalis; acids; paints and paint sludges; calcium fluoride sludges; methylene chloride; perchloroethylene; trichloroethane; acetone; methanol; toluene; PCBs
Electroplaters	Boric, hydrochloric, hydrofluoric, and sulfuric acids; sodium and potassium hydroxide; chromic acid; sodium and hydrogen cyanide; metallic salts
Foundries and metal fabricators	Paint wastes; acids; heavy metals; metal sludges; plating wastes; oils; solvents; explosive wastes
Furniture and fixtures manufacturers	Paints; solvents; degreasing sludges; solvent recovery sludges
Machine and metal working shops	Solvents; metals; miscellaneous organics; sludges; oily metal shavings; lubricant and cutting oils; degreasers (tetrachloroethylene); metal marking fluids; mould-release agents
Mining operations (surface and underground), underground storage mines	Mine spoils or tailings that often contain metals; acids; highly corrosive mineralized waters; metal sulfides
Unsealed abandoned mines used as waste pits	Metals; acids; minerals; sulfides; other hazardous and non-hazardous wastes
Paper mills	Metals; acids; minerals; sulfides; other hazardous and non-hazardous chemicals; organic sludges; sodium hydroxide; chlorine; hypochlorite; chlorine dioxide; hydrogen peroxide
Petroleum production and storage companies, secondary recovery of petroleum	Hydrocarbons; oil-field brines (highly mineralized salt solutions)
Industrial pipelines	Corrosive fluids; hydrocarbons; other hazardous and non-hazardous materials and wastes
Photo processing laboratories	Cyanides; biosludges; silver sludges; miscellaneous sludges
Plastic materials and synthetics producers	Solvents; oils; miscellaneous organics and inorganics (phenols, resins); paint wastes; cyanides; acids; alkalis; wastewater treatment sludges; cellulose esters; surfactant; glycols; phenols; formaldehyde; peroxides; etc.
Primary metal industries (blast furnaces, steel works, and rolling mills)	Heavy metal wastewater treatment sludge; pickling liquor; waste oil; ammonia scrubber liquor; acid tar sludge; alkaline cleaners; degreasing solvents; slag; metal dust
Publishers, printers, and allied industries	Solvents; inks; dyes; oils; miscellaneous organics; photographic chemicals
Public utilities (phone, electric, power, gas)	PCBs from transformers and capacitors; oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides from utility rights-of-way
Sawmills and planers	Treated wood residue (copper quinolate, mercury, sodium azide); tanner gas; paint sludges; solvents; creosote; coating and gluing wastes
Stone, clay, and glass manufacturers	Solvents; oils and grease; alkalis; acetic wastes; asbestos; heavy metal sludges; phenolic solids or sludges; metal finishing sludge
Welders	Oxygen, acetylene, ozone
Wood preserving facilities	Wood preservatives; creosote

INDUSTRIAL SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Material stockpiles (coal, metallic ores, phosphates, gypsum)	Acid drainage; other hazardous and non-hazardous wastes
Waste tailing ponds (commonly for the disposal of mining wastes)	Acids; metals; dissolved solids; radioactive ores; other hazardous and non-hazardous wastes
Transport and transfer stations (Trucking terminals and rail yards	Fuel tanks; repair shop wastes, other hazardous and non-hazardous wastes
Above-ground and underground storage tanks and containers	Heating oil; diesel and gasoline fuel; other petroleum products; hazardous and non-hazardous materials and wastes
Storage, treatment, and disposal ponds, lagoons, and other surface impoundments	Hazardous and non-hazardous liquid wastes; septage; sludge
Chemical landfills	Leachate; hazardous and non-hazardous wastes; nitrates
Radioactive waste disposal materials	Radioactive wastes from medical facilities Radionuclides (uranium, plutonium)
Unattended wet and dry excavation sites (unregulated dumps)	A wide range of substances; solid and liquid wastes; oil-field brines; spent acids from steel mill operations; snow removal piles containing large amounts of salt
Operating and abandoned production and exploratory wells (for gas, oil, coal, geothermal, and heat recovery); test hole wells; monitoring and excavation wells	Metals; acids; minerals; sulfides; other hazardous and non-hazardous chemicals
Dry wells	Saline water from wells pumped to keep them dry
Injection wells	Highly toxic wastes; hazardous and non-hazardous industrial wastes; oil-field brines
Well drilling operations	Brines associated with oil and gas operations

INDUSTRIAL SOURCES: PRESENTLY OPERATED OR TORN-DOWN FACILITIES

Source	Health, Environmental, or Aesthetic contaminant
Asphalt plants	Petroleum derivatives
Communications equipment	Nitric, hydrochloric, and sulfuric acid wastes; heavy metal sludges
Copper Manufacturers	Contaminated etchant (e.g. ammonium persulfate); cutting oil and degreasing solvent (trichloroethane, Freon, or trichloroethylene); waste oils; corrosive soldering flux; paint sludge; waste plating solution
Electric and electronic equipment	Cyanides; metal sludges; caustics (chromic acid); solvents; oils; manufacturers and storage facilities alkalis; acids, paints and paint sludges; calcium fluoride sludges; methylene chloride; perchloroethylene; trichloroethane; acetone; methanol; toluene; PCBs
Electroplaters	Boric, hydrochloric, hydrofluoric, and sulfuric acids; sodium and potassium hydroxide; chromic acid; sodium and hydrogen cyanide; metallic salts
Foundries and metal fabricators	Paint wastes; acids; heavy metals; metal sludges; plating wastes; oils; solvents; explosive wastes
Furniture and fixtures manufacturers	Paints; solvents; degreasing sludges; solvent recovery sludges
Machine and metal working shops	Solvents; metals; miscellaneous organics; sludges; oily metal shavings; lubricant and cutting oils; degreasers (tetrachloroethylene); metal marking fluids; mould-release agents
Mining operations (surface and underground), underground storage mines	Mine spoils or tailings that often contain metals; acids; highly corrosive mineralized waters; metal sulfides
Unsealed abandoned mines used as waste pits	Metals; acids; minerals; sulfides; other hazardous and non-hazardous wastes
Paper mills	Metals; acids; minerals; sulfides; other hazardous and non-hazardous chemicals; organic sludges; sodium hydroxide; chlorine; hypochlorite; chlorine dioxide; hydrogen peroxide
Petroleum production and storage companies, secondary recovery of petroleum	Hydrocarbons; oil-field brines (highly mineralized salt solutions)
Industrial pipelines	Corrosive fluids; hydrocarbons; other hazardous and non-hazardous materials and wastes
Photo processing laboratories	Cyanides; biosludges; silver sludges; miscellaneous sludges
Plastic materials and synthetics producers	Solvents; oils; miscellaneous organics and inorganics (phenols, resins); paint wastes; cyanides; acids; alkalis; wastewater treatment sludges; cellulose esters; surfactant; glycols; phenols; formaldehyde; peroxides, etc.
Primary metal industries (blast furnaces, steel works, and rolling mills)	Heavy metal wastewater treatment sludge; pickling liquor; waste oil; ammonia scrubber liquor; acid tar sludge; alkaline cleaners; degreasing solvents; slag; metal dust
Publishers, printers, and allied industries	Solvents; inks; dyes; oils; miscellaneous organics; photographic chemicals
Public utilities (phone, electric power, gas)	PCBs from transformers and capacitors; oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides from utility rights-of-way
Sawmills and planers	Treated wood residue (copper quinolate, mercury, sodium azide); tanner gas; paint sludges; solvents; creosote, coating and gluing wastes
Stone, clay, and glass manufacturers	Solvents; oils and grease; alkalis; acetic wastes; asbestos; heavy metal sludges; phenolic solids or sludges; metal finishing sludge
Welders	Oxygen, acetylene, ozone
Wood preserving facilities	Wood preservatives; creosote

RESIDENTIAL SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Asphalt and roofing tar	Hydrocarbons
Bug and tar removers	Xylene, petroleum distillates
Cesspool cleansers	Tetrachloroethylene, dichlorobenzene, methylene chloride
Cleaners (household, oven)	xylenes, glycol ethers, isopropanol
Disinfectants	disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); cresol, xylenols
Drain cleaners	1,1,1-trichloroethane, caustic soda
Heating oil, diesel fuel, kerosene	Hydrocarbons
Jewellery cleaners	Sodium cyanide
Laundry soil and stain removers, spot removers	Hydrocarbons, trichloroethylene, 1,1,1-trichloroethane
Lye or caustic soda	Sodium hydroxide
Metal polishes	Petroleum distillates, isopropanol, petroleum naphtha
Pesticides (household - all types)	Common household pesticides for controlling pests such as ants, termites, bees, wasps, flies, cockroaches, silverfish, mites, ticks, fleas, worms, rates, and mice can contain active ingredients including naphthalene, phosphorus, xylene, chloroform, heavy metals, chlorinated hydrocarbons, arsenic, strychnine, kerosene, nitrosamines, and dioxins
Photochemicals (photofinishing chemicals)	Phenols, sodium sulfite, cyanide, silver halide, potassium bromide
Printing ink	Heavy metals, phenol-formaldehyde
Refrigerants	Trichlorofluoroethane
Rustproofers	Phenols, heavy metals
Septic systems, cesspools, and sewer lines; cleaners	Septage: coliform and non-coliform bacteria; viruses; nitrates; heavy metals; synthetic detergents; cooking and motor oils; bleach; pesticides; paints; paint thinner; photographic chemicals; swimming pool chemicals; septic tank/cesspool cleaner chemicals elevated levels of chloride, sulfate, calcium, magnesium, potassium, and phosphate Septic tank/cesspool cleaners include synthetic organic chemicals such as 1,1,1 trichloroethane, tetrachloroethylene, carbon tetrachloride, and methylene chloride
Solvents	Acetone, benzene, xylene
Swimming pool disinfection and maintenance chemicals	Free and combined chlorine; bromine; iodine Copper-based, and quaternary algicides Cyanuric acid Calcium or sodium hypochlorite Muriatic acid Sodium carbonate
Toilet cleaners	Xylene, sulfonates, chlorinated phenols
Underground storage tanks	Home heating oil

MECHANICAL REPAIR AND OTHER MAINTENANCE PRODUCTS

Source	Health, Environmental, or Aesthetic contaminant
Antifreeze	Methanol, ethylene glycol
Antifreeze (gasoline or coolants systems)	Methanol, ethylene glycol
Automatic transmission fluid	Petroleum distillates, xylene
Battery acid (electrolyte)	Sulfuric acid, bromide
Car wash detergents	Alkyl benzene sulfonates
Car waxes and polishes	Petroleum distillates, hydrocarbons
Degreasers for driveways and garages	Petroleum solvents, alcohols, glycol ether
Degreasers for engines and metal	Chlorinated hydrocarbons, toluene, phenols, dichloroperchloroethylene
Engine and radiator flushes	Petroleum solvents, ketones, butanol, glycol ether
Gasoline and jet fuel	Hydrocarbons
Grease, lubricants	Hydrocarbons
Hydraulic fluid (brake fluid)	Hydrocarbons, fluorocarbons
Motor oils and waste oils	Hydrocarbons, heavy metals

LAWN AND GARDENS

Source	Health, Environmental, or Aesthetic contaminant
Fertilizers	Nitrogen
Herbicides and other pesticides	Common pesticides used for lawn and garden maintenance (i.e., weed killers, and mite, grub, and aphid controls) include such chemicals as 2,4-D; chlorpyrifos; diazinon; benomyl; captan; dicofol; and methoxychlor
Wood preservatives	Pentachlorophenols, creosote, copper, arsenic, metam sodium

WALL, FURNITURE AND FLOOR TREATMENT

Source	Health, Environmental, or Aesthetic contaminant
Floor and furniture strippers	Xylene
Paint and lacquer thinner	Acetone, benzene, toluene, butyl acetate, methyl ketones
Paint and varnish removers, deglossers	Methylene chloride, toluene, acetone, methanol, glycol ethers, methyl ethyl ether
Paint brush cleaners	Hydrocarbons, toluene, acetone, methanol, glycol ethers, methyl ethyl ketones
Paints, varnishes, stains, dyes	Heavy metals, toluene

RESIDENTIAL SOURCES

Source	Health, Environmental, or Aesthetic contaminant
Asphalt and roofing tar	Hydrocarbons
Bug and tar remover	Xylene, petroleum distillates
Carpet cleaners	Tetrachloroethylene, dichlorobenzene, methylene chloride
Cleaners (household, oven)	xylenes, glycol ethers, isopropanol
Disinfectants	disinfectants (quaternary ammonia, hexachlorophene, peroxides, chlornexade, bleach); cresol, xylenols
Drain cleaners	1,1,1-trichloroethane, caustic soda
Heating oil, diesel fuel, kerosene	Hydrocarbons
Jewelry cleaners	Sodium cyanide
Laundry soil and stain removers, spot removers	Hydrocarbons, trichloroethylene, 1,1,1-trichloroethane
Lye or caustic soda	Sodium hydroxide
Metal polishes	Petroleum distillates, isopropanol, petroleum naphtha
Pesticides (household - all types)	Common household pesticides for controlling pests such as ants, termites, bees, wasps, flies, cockroaches, silverfish, mites, ticks, fleas, worms, rates, and mice can contain active ingredients including naphthalene, phosphorus, xylene, chloroform, heavy metals, chlorinated hydrocarbons, arsenic, strychnine, kerosene, nitrosamines, and dioxins
Photochemicals (developing chemicals)	Phenols, sodium sulfite, cyanide, silver halide, potassium bromide
Printing ink	Heavy metals, phenol-formaldehyde
Refrigerants	Trichlorofluoroethane
Rustproofers	Phenols, heavy metals
Septic systems, cesspools and sewer lines cleaners	Septage; coliform and non-coliform bacteria; viruses; nitrates; heavy metals; synthetic detergents; cooking and motor oils; bleach; pesticides; paints; paint thinner; photographic chemicals; swimming pool chemicals; septic tank/cesspool cleaner chemicals elevated levels of chloride, sulfate, calcium, magnesium, potassium, and phosphate Septic tank/cesspool cleaners include synthetic organic chemicals such as 1,1,1 trichloroethane, tetrachloroethylene, carbon tetrachloride, and methylene chloride
Solvents	Acetone, benzene, xylene
Swimming pool disinfection and maintenance chemicals	Free and combined chlorine; bromine; iodine Copper-based, and quaternary algicides Cyanuric acid Calcium or sodium hypochlorite Muriatic acid Sodium carbonate
Toilet cleaners	Xylene, sulfonates, chlorinated phenols
Underground storage tanks	Home heating oil

MECHANICAL REPAIR AND OTHER MAINTENANCE PRODUCTS

Source	Health, Environmental, or Aesthetic contaminant
Antifreeze	Methanol, ethylene glycol
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Automatic transmission fluid	Petroleum distillates, xylene
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Car wash detergents	Alkyl benzene sulfonates
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Degreasers for driveways and garages	Petroleum solvents, alcohols, glycol ether
Degreasers for engines and metal	Chlorinated hydrocarbons, toluene, phenols, dichloroperchloroethylene
Engine and radiator flushes	Petroleum solvents, ketones, butanol, glycol ether
Gasoline and jet fuel	Hydrocarbons
Grease, lubricants	Hydrocarbons
Hydraulic fluid (brake fluid)	Hydrocarbons, fluorocarbons
Motor oils and waste oils	Hydrocarbons, heavy metals

LAWN AND GARDENS

Source	Health, Environmental, or Aesthetic contaminant
Fertilizers	Nitrogen
Herbicides and other pesticides	Common pesticides used for lawn and garden maintenance (i.e., weed killers, and mite, grub, and aphid controls) include such chemicals as 2,4-D; chlorpyrifos; diazinon; benomyl; captan; dicofol; and methoxychlor
Wood preservatives	Pentachlorophenols, creosote, copper, arsenic, metam sodium

WALL, FURNITURE AND FLOOR TREATMENT

Source	Health, Environmental, or Aesthetic contaminant
Floor and furniture strippers	Xylene
Paint and lacquer thinners	Acetone, benzene, toluene, butyl acetate, methyl ketones
Paint and varnish removers, deglossers	Methylene chloride, toluene, acetone, methanol, glycol ethers, methyl ethyl ether
Paint brush cleaners	Hydrocarbons, toluene, acetone, methanol, glycol ethers, methyl ethyl ketones
Paints, varnishes, stains, dyes	Heavy metals, toluene

Appendix 3.2 Setting up a GIS Database

A Geographic Information System (GIS) is capable of performing input, storage, retrieval, analysis, output, and display of geographically or spatially indexed data. An operational GIS allows users to encode, analyze and display data layers from a variety of sources, such as field notes, land use and zoning maps, topographic maps, aerial photographs and satellite images.

The first step in implementing a GIS project is to obtain digital spatial data of the area(s) of concern. It is important to evaluate this data based on the following criteria:

- scale
- accuracy
- level of detail
- date produced
- consistency with other data sets.

Once selected, spatial data can be encoded based on a commonly used coordinate system such as geographic coordinates (latitude/longitude) or UTM[8] coordinates. However, a large volume of data without proper geo-referencing[9] is available in paper format, and this data will need to be geo-referenced. Information on contaminant sources may also vary greatly in quality, depending on whether the information comes from anecdotal sources or has been field-checked. Once a GIS database is completed, data verification must be carried out to determine if the data are accurate, true and free of data entry errors.

The establishment of a GIS is a major undertaking. For most GIS applications, the gathering of the data is often the most resource intensive part of the exercise. A high level of staff training is required to make the GIS functional, but the benefits can outweigh the costs because it provides a visual representation of complex data sets. Professional assistance will be needed to set up a GIS system.

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[8] UTM: Universal Transverse Mercator

[9] In other words, the location has not been linked to its geographic coordinates

STEP THREE:
Documenting Potential Sources of Contaminants

Ian Rutherford (Valley District Engineer), Anne Jones (Environmental Health Officer), and Devon Alexander (Pumphandle Valley Conservation Society) approached the Valley District High School to help with the contaminant survey.

Gather Available Information

Students and instructors from the Valley District High School agreed to conduct a contaminant inventory as a year-long science project. Cadastral maps (1:2,000) for the well protection area were obtained from the Regional District and given to the students.

The students' first task was to gather information on potential contaminant sources. They obtained air photos and soil maps of the area from Maps BC, and zoning maps from the Regional District. They also called staff from the Ministry of Environment, Lands and Parks and Pumphandle Community Health Services Society to determine current and past activities or facilities that had been given permits. Anne Jones identified all the areas with septic systems in the well protection area and helped the students to map them out. Ministry of Environment, Lands and Parks staff searched their databases to check for permitted discharges, the existence of contaminated sites and reported spills in the protection area. Funding for the search was provided by the community planning team.

Conduct Surveys

The students chose to conduct different types of surveys for different source activities. The land use on agricultural lands was mapped from a windshield survey (with the teacher driving). The students then contacted and interviewed the farmers. They found that Simon Lee, the farmer who owned and maintained the hay (A-4) and corn (A-5) fields (see Figure CS 3.1), did not use fertilizer on his hay fields but did use manure, inorganic fertilizer and a small amount of atrazine (pesticide) on his cornfields. Simon is a member of the Pumphandle team and has already implemented Best Management Practices on his farm. Interviews and field visits to a neighbouring farmer revealed that there is an abandoned well in a hay field (A-3) next to the poultry barn. This abandoned well is a concern because it provides a potential route for contaminants to enter the aquifer.

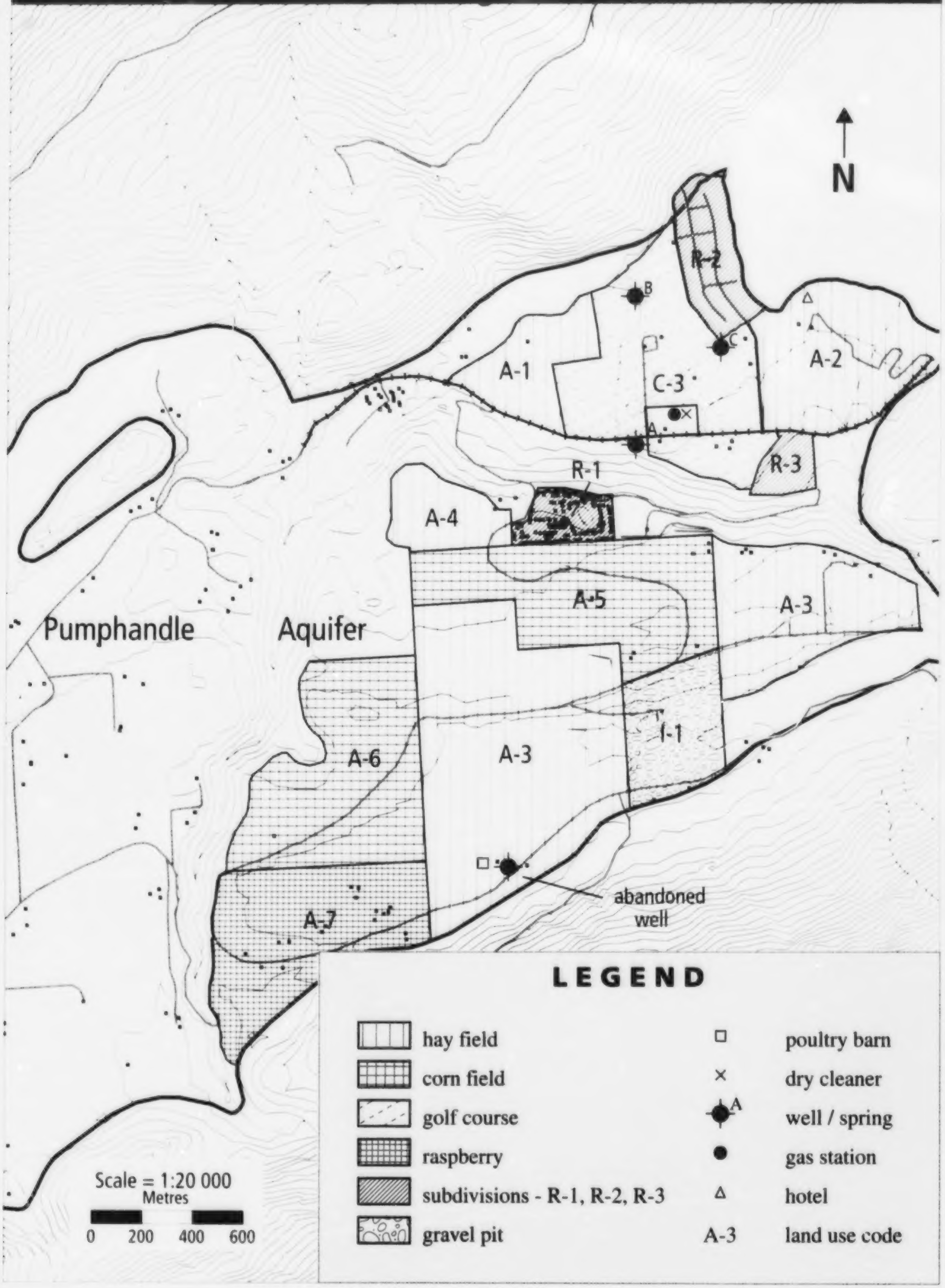
At the subdivisions, (R-1, 2, and 3), the students conducted door-to-door surveys to determine residents' household waste and gardening practices. Results of the surveys indicate that the use of fertilizers and pesticides is relatively high. Major household chemicals are paints and solvents stored in garages and sheds. Some residents did not know about the Regional District recycling programs and where or how they can properly store and dispose of household hazardous wastes.

A site inspection of the gas station yielded information on existing management practices and an inventory of on-site potential contaminants. The gas station has a tank that is 20 years old, which has not been tested for leaks for over ten years. A site inspection of the golf course (C-3) revealed that substantial amounts of both pesticides and inorganic fertilizers are applied to the greens and fairways from April to November. A site visit to the gravel pit (I-1) indicated that there is no gravel processing on site and the main activity is hauling gravel away.

Record Information

All the potential sources were mapped on a 1:20,000 TRIM map overlay (Figure CS 3.1). Information on the potential contaminant sources was entered onto a spreadsheet. The potential contaminant sources identified by the students are shown in Table CS 3.1. Once the survey was completed, the community planning team verified the results through field inspections of specified sites.

FIGURE CS 3.1 INVENTORY OF CONTAMINANT SOURCES



N
R-2
B
C
A-2
A-1
C-3
A
R-3
R-1
A-4
A-5
A-3
Pumphandle
Aquifer
I-1
A-6
A-3
abandoned well
A-7
LEGEND
hay field
corn field
golf course
raspberry
subdivisions - R-1, R-2, R-3
gravel pit
poultry barn
dry cleaner
well / spring
gas station
hotel
A-3 land use code
Scale = 1:20 000
Metres
0 200 400 600

Set Priorities

The Pumphandle team met to establish priorities for the potential contaminant sources. They suggested:

1. **The highest priority sources include the golf course (C-3), gas station (C-1), dry cleaner (C-4), subdivision (R-1 and R-2), a corn field (A-5), hayfields (A-1 and A-4) and the main road (T-1).**

   These sites are all within the one-year time of travel zone for at least one of the wells, or are close to one of the wells. All have multiple sources of contamination such as septic fields, pesticide and fertilizer applications, solvents and gasoline storage or where the consequence of contamination would be severe.

2. **The lower priority sources include the other corn/hay fields (A-2, A-3, A-6) and gravel pit (I-1), hotel (C-2), poultry barn (A-3) and abandoned well (A-3).**

The corn/hay fields and gravel pit were given a lower priority since they are located further from the well sources. The team could consider dealing with these sites earlier in the process by letting the owners know about Best Management Practices. The abandoned well and poultry barn are located beyond the one-year time of travel distance from the community wells.

Update Information

The planning team agreed to review the land uses and practices and update the database and the land use map annually. Data from the contaminant survey were initially entered and stored in a spreadsheet in MS-Excel. The data were eventually uploaded to the Valley Regional District geographic information system (GIS).

M121

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TABLE CS3.1 SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	<1-YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE	
1st Priority A-1 hay field (15.4)	Ed Kotischyn	Blackwater Well					
2nd Priority A-2 hay field (34.1)	Janis Lobey		Charlie's Well				
2nd Priority A-3 hay field (114.4)	Jim Summer		Blackwater Well		Aiken's Well		
2nd Priority A-3 manure storage at poultry farm	Jim Summer		Blackwater Well				
2nd Priority A-3 abandoned well	Jim Summer		Blackwater Well				
1st Priority A-4 hay field (12.3)	Simon Lee	Blackwater Well					
1st Priority A-5 corn field ([illegible])	Simon Lee		Blackwater Well		Aiken's Well		
2nd Priority A-6 corn field ([illegible])	Manjit Dhaliwal					Blackwater Well	

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
NO_3 from fertilizers	Grows hay for feed; broadcasts fertilizers (15-15-10) three times a year from spring to fall	Fertilizers stored on pallets on cement floor in shed; shed is 30 m from pumphandle Creek	Septic system
NO_3 from fertilizers NO_3 from former corn field?	Grows hay for grazing; broadcasts fertilizers (15-15-10) once a year from spring to fall (60 kg/ha)	Fertilizers stored on pallets on cement floor in shed; private well is 30 m uphill (south) of shed	Septic system
NO_3 from mixing fertilizer chemicals	Grows hay for feed; broadcasts fertilizers (15-15-10) three times a year from spring to fall (55-80 kg/ha); also uses poultry manure	Fertilizers stored on pallets on cement floor in shed; well is 10 m from shed	Septic system
NO_3 from manure leachate	15,000 leghorns; follows Code of Practice, cleans out poultry barn every spring, uses some of the manure for hayfield, sells rest to other farmers in the area	Manure stockpiled in spring but covered with tarp	
A potential pathway for contaminants dumped down the well	Well is not used, the wellhead is covered with a 5-gal pail	N/A	
NO_3 from fertilizers	Grows hay for grazing; uses poultry manure once a year (2 truckloads/ha or 30 kg N/ha)		
Pesticides, NO_3 from fertilizers	Grows [illegible] and Supersweet Jubilee variety of corn; uses poultry manure from A-3 and elsewhere (1 truckload/ha or 25 kg N/ha) and inorganic fertilizer (15-30-25), applied in spring before and after seeding (10 kg N/ha); uses atrazine 500 for weed control (1.5 L/ha); fertilizer application not based soil testing	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets and pesticides in cabinets; the private well is located 200 m to the northeast	Septic System
Pesticides, NO_3 from fertilizers	Grows Supersweet Jubilee variety of corn; uses poultry manure from A-3 and elsewhere (1 truckload/ha) and inorganic fertilizer (15-20-20), applied in spring before and after seeding (10 kg N/ha); uses atrazine 500 for weed control (0.5 to 0.3 L/ha); fertilizer application not based on soil testing	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets on concrete floor and pesticides on shelves; the privates well are located 200 and 350 m to the northeast	Septic system

TABLE CS3.1 SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	<1-YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
1st Priority A-1 hay field (15.4)	Ed Kotischyn	Blackwater Well				
2nd Priority A-2 hay field (34.1)	Janis Lobey		Charlie's Well			
2nd Priority A-3 hay field (114.4)	Jim Summer		Blackwater Well		Aiken's Well	
2nd Priority A-3 manure storage at poultry farm	Jim Summer		Blackwater Well			
2nd Priority A-3 abandoned well	Jim Summer		Blackwater Well			
1st Priority A-4 hay field (12.3)	Simon Lee	Blackwater Well				
1st Priority A-5 corn field (44.3)	Simon Lee		Blackwater Well		Aiken's Well	
2nd Priority A-6 corn field (46.7)	Manjit Dhaliwal					Blackwater Well

FOR PUMPHANDLE WELLS

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
NO_3 from fertilizers	**Grows hay for feed; broadcasts fertilizers (15-15-10) three times a year from spring to fall**	Fertilizers stored on pallets on cement floor in shed; shed is 30 m from pumphandle Creek	**Septic system**
NO_3 from fertilizers NO_3 from former corn field?	**Grows hay for grazing; broadcasts fertilizers (15-15-10) once a year from spring to fall (60 Kg/ha)**	Fertilizers stored on pallets on cement floor in shed; private well is 30 m uphill (south) of shed	**Septic system**
NO_3 from mixing fertilizer chemicals	**Grows hay for feed; broadcasts fertilizers (15-15-10) three times a year from spring to fall (55-80 Kg/ha), also uses poultry manure**	Fertilizers stored on pallets on cement floor in shed; well is 10 m from shed	**Septic system**
NO_3 from manure leachate	**15,000 leghorns; follows Code of Practice, cleans out poultry barn every spring, uses some of the manure for hayfield, sells rest to other farmers in the area**	Manure stockpiled in spring but covered with tarp	
A potential pathway for contaminants dumped down the well	**Well is not used, the wellhead is covered with a 5-gal pail**	N/A	
NO_3 from fertilizers	**Grows hay for grazing; uses poultry manure once a year (2 truckloads/ha or 50 Kg N/ha)**		
Pesticides, NO_3 from fertilizers	**Grows Terrific and Supersweet Jubilee variety of corn; uses poultry manure from A-3 and elsewhere (1 truckload/ha or 25 Kg N/ha) and inorganic fertilizer (15-20-25), applied in spring before and after seeding (10 Kg N/ha); uses atrazine 500 for weed control (3.5 L/ha); fertilizer application not based soil testing**	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets and pesticides in cabinets; the private well is located 200 m to the northeast	**Septic System**
Pesticides, NO_3 from fertilizers	**Grows Supersweet Jubilee variety of corn; uses poultry manure from A-3 and elsewhere (1 truckload/ha) and inorganic fertilizer (15-20-25), applied in spring before and after seeding (20 kg N/ha); uses atrazine 500 for weed control (3.5 to 4.5 L/ha); fertilizer application not based on soil testing**	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets on concrete floor and pesticides on shelves; the privates well are located 200 and 350 m to the northeast	**Septic system**

TABLE CS3.1 SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	<1-YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
2nd Priority A-7 raspberry farm (40.7)	Manjit Dhaliwal					**Blackwater Well**
1st Priority C-1 gas station	Fred Kobeck			**Charlie's Well**	Aiken's Well	
2nd Priority C-2-hotel	Tim & Judy Sonoff					**Charlie's Well**
1st Priority C-3 golf course (46.4)	Jack Sonoff	**Blackwater Well and Charlie's Well**			Aiken's Well	
1st Priority C-4 dry cleaner	Linda and Andrew Winters			**Charlie's Well**	Aiken's Well	
2nd Priority I-1-gravel pit (19.3)	Joe Mielo				Aiken's Well	
1st Priority R-1 subdivision (7.2)	Jenny Lowden strata president				Aiken's Well	
1st Priority R-2 subdivision and campground (13.5)	Jocelyne Dufour campground owner and operator	**Charlie's Well**				

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
Pesticides, NO_3 from fertilizers	**Grows Chilliwack variety of raspberry; uses poultry manure as a soil conditioner/fertilizer (1 truckload/ha) and inorganic fertilizers (10-16-18), applied in the spring (30 Kg N/ha); uses minor amounts of simazine and diazinon for weed and pest control (amounts not known); fertilizer application not based on soil testing**	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets and pesticides on shelves; the private well is located 100 m to the north	**Septic system**
Gasoline, pathogens & NO_3 from septic system, oils, chemicals	**The tank is 20 years old and was tested for leaks in 1987 (none were found at the time); oils and solvents were stored in 45 gallon drums and taken to the regional landfill every week for disposal**	Motor oil displayed in cashier area that is indoors and contained	**Septic system is 35 m from Aiken's well**
Pathogens & NO_3 from septic system	**Uses cleaners and some solvents; uses garden fertilizers and lime for the lawn and Round-Up on the flower beds for weed control**	Cleaners and solvents are stored in the janitorial room; wash water with cleaners are poured down the drains	**Septic system is 40 m from Pumphandle Lake**
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system	**Uses fertilizers (20-20-10) and pesticides; light application of slow release fertilizer in late fall (amounts not reported); application of rapid release fertilizer in spring; application based on soil testing**	Fertilizers and pesticides stored in physical plant shed, shed has a concrete floor; the shed is located 100 m south of Blackwater well and 150 m west of Charlie's well	Septic system
Solvents	**Uses dry cleaning chemicals**	Chemicals stored in locked cabinet	Septic system
None	**Extract gravel and truck off-site; no processing**	Motor oil stored in office	Septic system
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	**Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented**	Some latex paints and motor oil stored in garden shed, along with the fertilizers and pesticides	**Septic system density is high (28/ha)**
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	**Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented**	Latex and oil-based paints, thinners and motor oil stored in residential garages, along with the fertilizers and pesticides;	**Septic system density is moderate (2-3/ha)**

TABLE CS3.1 SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	< 1 YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
2nd Priority A-7 raspberry farm (40.7)	Manjit Dhaliwal					Blackwater Well
1st Priority C-1 gas station	Fred Kobeck			Charlie's Well	Aiken's Well	
2nd Priority C-2-motel	Tim & Judy Sonoff					Charlie's Well
1st Priority C-3 golf course (66.4)	Jack Sonoff	Blackwater Well and Charlie's Well			Aiken's Well	
1st Priority C-4 dry cleaner	Linda and Andrew Winters			Charlie's Well	Aiken's Well	
2nd Priority I-1-gravel pit (10.3)	Joe Mielo				Aiken's Well	
1st Priority R-1 subdivision (7.0)	Jenny Lowden strata president				Aiken's Well	
1st Priority R-2 subdivision and campground (12.3)	Jocelyne Dufour campground owner and operator	Charlie's Well				

FOR PUMPHANDLE WELLS CONTINUED

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
Pesticides, NO_3 from fertilizers	Grows Chilliwack variety of raspberry; uses poultry manure as a soil conditioner/fertilizer (1 truckload/ha) and inorganic fertilizers (10-16-18), applied in the spring (30 Kg N/ha); uses minor amounts of simazine and diazinon for weed and pest control (amounts not known); fertilizer application not based on soil testing	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets and pesticides on shelves; the private well is located 100 m to the north	Septic system
Gasoline, pathogens & NO_3 from septic system, oils, chemicals	The tank is 20 years old and was tested for leaks in 1987 (none were found at the time); oils and solvents were stored in 45 gallon drums and taken to the regional landfill every week for disposal	Motor oil displayed in cashier area that is indoors and contained	Septic system is 35 m from Allen's well
Pathogens & NO_3 from septic system	Uses cleaners and some solvents; uses garden fertilizers and lime for the lawn and Round-Up on the flower beds for weed control	Cleaners and solvents are stored in the janitorial room; wash water with cleaners are poured down the drains	Septic system is 40 m from Pumphandle Lake
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system	Uses fertilizers (20-20-10) and pesticides; light application of slow release fertilizer in late fall (amounts not reported); application of rapid release fertilizer in spring; application based on soil testing	Fertilizers and pesticides stored in physical plant shed, shed has a concrete floor; the shed is located 100 m south of Blackwater well and 150 m west of Charlie's well	Septic system
Solvents	Uses dry cleaning chemicals	Chemicals stored in locked cabinet	Septic system
None	Extract gravel and truck off-site; no processing	Motor oil stored in office	Septic system
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented	Some latex paints and motor oil stored in garden shed, along with the fertilizers and pesticides	Septic system density is high (20/ha)
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented	Latex and oil-based paints, thinners and motor oil stored in residential garages, along with the fertilizers and pesticides;	Septic system density is moderate (2-3/ha)

TABLE CS3.1 SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	<1 YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE	
2nd Priority R-3 subdivision (4.3)	Eric Kowski strata president					Charlie's Well	
1st Priority T-1 main road	Valley Regional District	Blackwater Well		Charlie's Well	Aiken's Well		

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented	Some latex paints and motor oil stored in garden shed, along with the fertilizers and pesticides	Septic system density is moderate (3/ha)
De-icing chemicals	Uses de-icing chemicals during freezing conditions (up to 20 times a year between Nov-Feb)	Chemicals stored in works yard 4 Km out of town	

TABLE CS3.1 SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	<1-YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
2nd Priority **R-3** **subdivision** **(4.9)**	Eric Kowski strata president					**Charlie's Well**
1st Priority **T-1** **main road**	Valley Regional District	**Blackwater Well**		**Charlie's Well**	Aiken's Well	

FOR PUMPHANDLE WELLS CONTINUED

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	**Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented**	Some latex paints and motor oil stored in garden shed, along with the fertilizers and pesticides	**Septic system density is moderate (3/ha)**
De-icing chemicals	**Uses de-icing chemicals during freezing conditions (up to 20 times a year between Nov-Feb)**	Chemicals stored in works yard 4 Km out of town	

NOTES

Step Four

DEVELOP MANAGEMENT STRATEGIES

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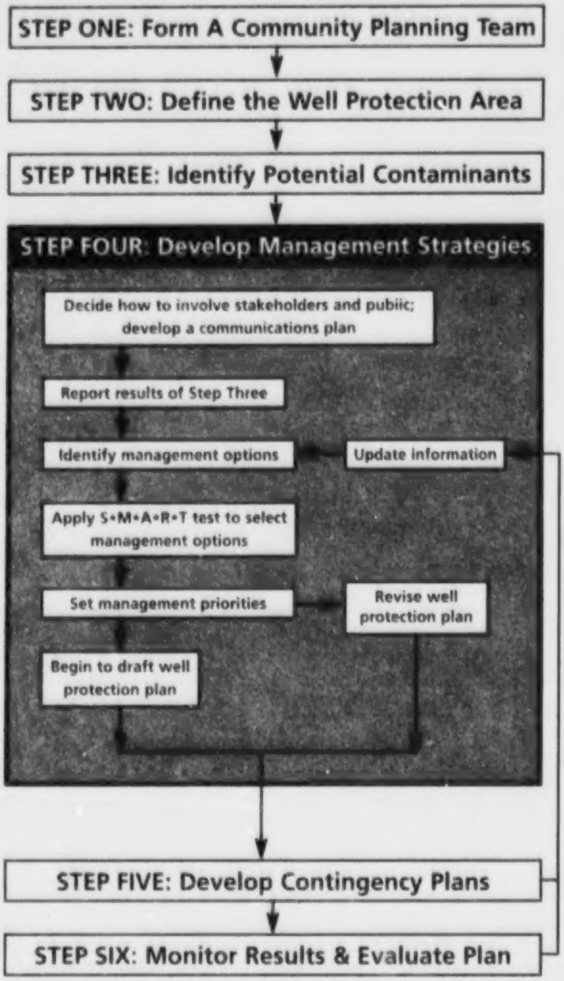
STEP ONE: Form A Community Planning Team
STEP TWO: Define the Well Protection Area
STEP THREE: Identify Potential Contaminants
STEP FOUR: Develop Management Strategies
Decide how to involve stakeholders and public; develop a communications plan
Report results of Step Three
Identify management options
Update information
Apply S•M•A•R•T test to select management options
Set management priorities
Revise well protection plan
Begin to draft well protection plan
STEP FIVE: Develop Contingency Plans
STEP SIX: Monitor Results & Evaluate Plan

More than 750,000 British Columbians rely on groundwater as their source of drinking water, and there are thousands of community well systems in British Columbia. A well protection plan allows communities to identify land use activities that may threaten the quality of their well water, and to develop a strategy to avoid or minimize these threats.

There are six steps to follow in developing a well protection plan:

1. Form a community planning team
2. Define the well protection area
3. Identify potential contaminants
4. Develop and implement management strategies
5. Develop contingency plans
6. Monitor results and evaluate the plan

These steps are described in the six booklets that make up the *Well Protection Toolkit*. Each booklet describes activities that lead to the development and implementation of a well protection plan. In each step, a fictional case study of the town of Pumphandle shows how one community took on this challenge.

Step Four: Develop Management Strategies

The fourth step is to identify a range of appropriate management options, and to determine priorities for action. The S*M*A*R*T test is used to assess which management options should be adopted. This is the time to begin writing the well protection plan.

It is important to keep stakeholders and the public informed and involved throughout the well protection planning, but it is essential for this step because public support can help the success of the plan.

Figure 4.1 shows the stages of Step Four.

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Develop Management Strategies

OBJECTIVES

- To use a variety of management approaches to prevent contamination
- To identify management options for all potential contaminant sources in the well protection area
- To assess management options and set priorities
- To set schedules for implementation
- To begin to draft the well protection plan

During Step Three, sources of potential contaminants in the well protection area were identified and mapped, and sources for priority action were identified. The next task is to determine the best way to manage these potential contaminant sources, and to decide which actions should be implemented first. The planning team can then begin drafting the action items for the well protection plan.

As you develop the management strategies, think about how you will evaluate them (Step Six).

4.1 Generate Public Support

Managing activities in the well protection area requires support and commitment from stakeholders[1] and residents of the community. A public information process is vital throughout the development of the well protection plan. During Step One, the planning team provided basic information on the well protection planning process through flyers and public meetings. During Step Three, there were articles in the local media, and some people were made aware of the well protection process through surveys. At this fourth step, it is again a good idea to ensure that the community at large has an opportunity to learn about and comment on the survey results and proposed management options (Sections 4.2 to 4.4).

During the surveys, stakeholders and residents often ask questions such as "Why is this information being collected?" and "How will this information be used?" You need to report the survey findings back to the people surveyed. One way to do this, and to involve the public in developing the well protection strategy for their community, is to present your findings at a public meeting.

"Public involvement" should bring stakeholders, residents and the planning team together to review the results from Step Three, and to identify and evaluate the management options available for each of the various potential contaminant sources. To ensure the widest public support, consider the following during the public consultation process:

- Inform the public from the outset that their input is needed to develop the well protection plan;
- Explore a variety of public views;
- Use the specialized knowledge and expertise available in the community;
- Use brainstorming to gather ideas for the protection strategy;
- Be open and democratic;
- Find ways to resolve conflict and controversy; and
- Develop public support and commitment for the protection strategy.

4.2 Identify Management Options

Management options fall into two broad categories: regulatory and non-regulatory options[2] (see Appendix 4.1). A regulatory option is based on laws or regulations and can be enforced. An example

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[1] A "stakeholder" is anyone who has an interest in or may be affected by the well protection plan (e.g. business owners, residents, conservation groups and governments agencies)

[2] An overview of regulatory and non-regulatory options can be found in: Environment Canada, 1995. *Groundwater Quality Protection Practices.* Prepared by Golder Associates Ltd. for the Fraser Valley Action Plan; and U.S. Environmental Protection Agency, 1993. *Wellhead Protection: A Guide for Small Communities.* EPA/625/R-93/002 report, 144pp.

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Management options fall into two broad categories: regulatory and non-regulatory options[2] (see Appendix 4.1). A regulatory option is based on laws or regulations and can be enforced. An example would be a land-use by-law that requires proposed developments in the well protection area to identify and address potential impacts on groundwater. Non-regulatory options are voluntary – they cannot be enforced. An example would be educating landowners about the best ways to minimize their impact on groundwater.

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Focus on Prevention

Management options should focus on prevention. It is much cheaper to prevent groundwater contamination than it is to restore a contaminated drinking water supply. Most B.C. communities have not yet experienced severe water quality problems, and will be able to focus on prevention when developing management options for the protection of their well.

Apply Differential Management

"Differential management" means using a variety of different approaches throughout the well protection area. The approach used will depend on the type of activity and its location relative to the well. Even two sources of the same type (e.g. two storage yards) may be managed differently. For example, one way to manage a storage yard close to the well (where the threat of pollution is high) might be to purchase the land and directly control future land use activities. Another storage yard, located in the ten-year time of travel area, could be managed through a public education program, and by working with the landowner to minimize impacts on groundwater. Differential management allows the planning team to focus its efforts and resources on the highest priority contaminant sources.

Identify a Full Range of Management Options for Each Source

A range of possible management options should be identified for every single potential contaminant source in the well protection area. Options are based on the results of the contaminant survey in Step Three, the location of the source in relation to the well protection area, and knowledge of the various options available.

There are several ways to identify management options for each potential contaminant source:

- Refer to generic checklists of management options such as those found in groundwater protection guidance documents;[3]
- Consult with government staff that have jurisdiction over particular activities, and with consultants and industry associations;
- Consult with the public to get local knowledge and expertise; and
- Seek advice from other communities that have completed a well protection plan.[4]

When identifying possible management options, look at the area as a whole, as well as at specific sources. Decide how policies and practices could be used to minimize future impacts on groundwater. What is the best way to reach your audience? For example, it may be effective to work with a berry growers' association to address proper fertilizer practices to all farmers in the area, in addition to working with specific farmers. The British Columbia Federation of Agriculture can help you identify the agricultural association(s) in your area.

Identify Agencies with Jurisdiction and Resources

Find out which agencies have regulatory control over potential contaminant sources. The government representative on the planning team may be able to identify government agencies that regulate these activities.

Government agencies and industry associations can also be great sources of advice on possible management options. Operators in the well protection area may have contacts with the particular association for their business. These business and industry associations can often provide background information on the activities and programs to help control their impacts on the environment.

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[3] Environment Canada, 1995. *Groundwater Quality Protection Practices.* Prepared by Golder Associates Ltd. for the Fraser River Action Plan; U.S. Environmental Protection Agency, 1994. *Ground Water and Wellhead Protection Handbook.* EPA/625/R-94/001, 269pp.; U.S. Environmental Protection Agency, 1993. *Wellhead Protection: A Guide for Small Communities.* EPA/625/R-93/002 report, 144pp.

[4] The Ministry of Environment, Lands and Parks or Ministry of Health in Victoria can provide you with a list of communities that have completed well protection plans.

The Ministry of Environment, Lands and Parks has funded the B.C. Recycling Hotline,[5] which provides information on waste reduction and household hazardous products. The Ministry is also responsible for product stewardship regulations. For example, the Post-Consumer Paint Stewardship Program Regulation requires every brand owner and seller of consumer paint products to arrange for the collection, transportation and final treatment of paint that is no longer wanted by consumers, and to incorporate the principles of pollution prevention in the stewardship of consumer paint products. There is also information on Integrated Pest Management at the Ministry's web site at http://www.elp.bc.ca/epd/epdpa/eripm/imphome.html

There are many sources of written information. Government agencies, associations, and pollution prevention and toxic reduction programs from other jurisdictions have manuals on Best Management Practices, pollution prevention guides, technical programs and expertise which may be relevant to the activities in your well protection area. Unfortunately, there is no current comprehensive listing of the guides and manuals. You may need help from your local librarian, or to conduct your own Internet search for the information.

4.3 Select the Appropriate Management Options

Once you have identified a range of possible management options for each source, you will need to evaluate these options to decide which are the most appropriate and effective.

To help you do this, apply the S*M*A*R*T test to assess and compare management options. S*M*A*R*T stands for Specific, Measurable, Achievable, Realistic and Time-bound.

Think S*M*A*R*T

Specific

Measurable

Achievable

Realistic

Time-bound

- **SPECIFIC**
  Is the management option specific, and the responsibility identified? What is to be done? Who is going to do it? For example, "educating the public on septic system maintenance" may be a general component in the protection strategy. A *specific* management option might be: "The environmental group will prepare a newsletter on septic system maintenance and how it benefits groundwater protection, and the water purveyor will distribute it to local residents with their water bill."
- **MEASURABLE**
  Can the success or failure of the management option be measured? What indicators will you use to measure this? Using the newsletter example, the design, production and distribution of the newsletter are easily measurable. The impact of the newsletter in changing people's behaviour is harder to measure, but can be done through a follow-up phone or door-to-door survey (especially if an initial survey provides information on "pre-newsletter" behaviours). This kind of follow-up is reasonable, especially if the newsletter is part of a series.
- **ACHIEVABLE**
  Can the management option be achieved in practice? Are there sufficient funds and technical resources to complete the task? The newsletter can be developed on a home computer by the planning team member and distributed as part of the water bill. This is achievable.

---

[5] Call 1-800-667-4321 (or 732-9253 in the Lower Mainland) for the B.C. Recycling Hotline, or go to the Ministry web site at http://www.elp.gov.bc.ca/epd/epdpa/pppm/ipshhp/ipshhp.html

- **REALISTIC**
  Can this management option be successfully implemented? Is it cost-effective? What are the risks? Will it have public support, or generate controversy? The likely effectiveness of the management option is also evaluated here. The newsletter is likely to be at least somewhat effective because it is not controversial, carries little risk and is an inexpensive way to get the message of septic system maintenance and groundwater protection to every household. Additional public education can also occur through direct public contact in follow-up surveys.
- **TIME-BOUND**
  Can this option be achieved within a reasonable time period, according to the schedule? Scheduling is important because some activities cannot be implemented until other tasks have been completed. The scheduling of the newsletter is governed by the time required to design and produce the newsletter, availability of resources, the date water bills are sent out and the way the newsletter will be coordinated with other public education and groundwater protection management initiatives.

The S*M*A*R*T test helps you to choose management options that will work. It allows the various management options to be evaluated and compared in a systematic and objective way, and so makes the final selection of options fair and accountable.

The management options that pass the S*M*A*R*T test are the ones that should be considered for implementation. Keep the original list of all the possible management options – you can refer to it again in the annual review. It may be that some of the conditions which caused the option to fail the S*M*A*R*T test are no longer a concern, and you may want to reconsider this option.

If all of the management options for a given source fail the S*M*A*R*T test, then it's time to think more creatively. Are there other options you hadn't previously considered? Can you modify some of the proposed options so they become S*M*A*R*T?

4.4 Set Priorities for the Implementation of Management Options

Not all of the S*M*A*R*T options will implemented at once. For each option that passes the S*M*A*R*T test, decide whether it should be a priority for immediate action or scheduled for later action.

Setting priorities for implementation makes sense because a community usually has a limited amount of resources and energy and cannot do everything at once. Some management activities may have to be implemented sequentially (one task needs to be completed before another one can start). Develop a schedule with items for immediate action, and actions that will take place as second or third priorities. The schedule of implementation will likely span several years as this is usually the time needed to implement many of the options, such as public education programs, revising regulations and persuading landowners to improve land use practices.

Factors to consider in setting priorities include contaminant priority, cost-effectiveness and ease of implementation. In developing priorities for implementation, all these factors need to be considered together. Each is discussed briefly below.

Contaminant Priority

Some contaminant sources will be rated as a high priority. This may be because the potential for contamination is high (for example, a golf course that regularly over-fertilizes), or because the consequences of contamination would be very severe (such as a chemical spill on the highway close to the wellhead).

Priorities for each source were set in Step Three, based on the distance between the source and well, and the aquifer's vulnerability. Management actions should also be implemented first in the most critical areas, usually those areas closest to the well. For example, actions may focus initially in the one- or five-year time of travel areas, and any highly vulnerable areas. Implementation in more distant and less vulnerable areas would take place later, as more resources become available.

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Cost-effectiveness

Where there is more than one management option for a given source, look at which option is most cost-effective and implement it first. Other options that are only marginally cost-effective may not have to be implemented at all.

Ease of Implementation

Where possible, choose management options that are relatively easy to implement. Implementing the easy options first builds momentum and confidence within the planning team and the community.

Although the community may wish to start by implementing the easiest and most-cost effective solutions, the protection plan may require significant efforts, involving some difficult decisions and associated costs. However, by using the S*M*A*R*T method, the community should be able to always implement what is possible for them to do.

4.5 Draft the Well Protection Plan

You now have all the elements required to begin drafting the well protection plan. A sample table of contents for this plan is shown in Appendix 4.2.

The well protection plan is a written document to which the community can refer. In writing the plan, be specific and concise. What are the concerns? What is to be done, and why? How will it be done? Who will do the work? By what date? Anyone who reads the plan document should be clear about the "what, why, how, who and when." Include maps and figures to show the well protection area, location of well(s), geographic features of the local area, and the location of potential contamination sources, etc. which give the reader a picture of the area. An example of a draft well protection plan is included with this *Toolkit*.

It is a good idea to have the draft plan reviewed before being finalized so anything that is unclear or missing can be addressed. The planning team should review the plan on a yearly basis.

CHECKLIST FOR STEP FOUR

The following is a basic checklist for action items to be completed during Step Four of the well protection planning process:

ACTION ITEM	COMMENTS	COMPLETED
Decide who is responsible for this action	Enlist consultants, technical and volunteer assistance if required.	☐
Decide how stakeholders will be involved	Hold public meetings to invite input from the community.	☐
Report results of survey to the public	Public meetings, articles in the media are options.	☐
Identify managment options	Develop a range of options for each potential contaminant source identified in Step Three.	☐
Apply the S*M*A*R*T test	Select the management options that work, or modify proposed options so that they work.	☐
Set priorities	Determine which management options should be applied first.	☐
Begin to draft the well protection plan	See sample table of contents (Appendix 4.2).	☐
Update information	Determine how often information will be reviewed.	☐

Cost-effectiveness

Where there is more than one management option for a given source, look at which option is most cost-effective and implement it first. Other options that are only marginally cost-effective may not have to be implemented at all.

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Update information	Determine how often information will be reviewed.	☐

Appendix 4.1 Summary of Regulatory and Non-Regulatory Tools for Well Protection Planning

Regulatory Tools

The Provincial Legislative Framework

British Columbia has a number of provincial laws and regulations that have a degree of control over groundwater protection. Table 4.1 lists the current provincial regulations, the lead government agency and a brief description of the legislation. The Acts are administered independently by various agencies within government.

Local Regulations and By-laws

Local government receives its power from the provincial government, and these powers are explicitly delegated through the *Municipal Act*. Municipalities (cities, towns or villages) and regional districts (which may include one or more municipalities and electoral districts) may exercise these local powers.

Working Together

Coordination between different jurisdictions in implementing protection measures is vital. A well protection plan focuses the coordination of the various Acts within a well protection area and encourages individuals, local governments, and provincial agencies to work together towards a common objective. For example, if the well protection area for a community well straddles two regional districts, protection measures such as land zoning or approvals within the protection area should be coordinated between the two jurisdictions.

Since many of the water purveyors do not own or control all of the land that falls within their protection areas, an effective well protection plan must have the cooperation of those who do have control over the land, such as local government, developers, landowners, and other individuals and agencies.

Common Law

According to the common law, a person cannot contaminate someone else's water if the result of that contamination is to cause damage to the well owner. In such cases, there may be a right of action in nuisance and/or negligence. Also, the contamination of water may be a contravention of provincial environmental and health statutes.

The quality of groundwater in wells has no formal protection. At this time, there is no licensing of groundwater so the extraction and use of groundwater is not generally regulated.

Non-Regulatory Tools

Non-regulatory tools are described in Table 4.2.

TABLE 4.1 EXISTING PROVINCIAL LEGISLATION (CURRENT AS OF 1999)

Legislation (Lead Agency)	Description
Municipal Act Ministry of Municipal Affairs	The Act allows for the • organization of municipalities, improvement districts, regional districts; • provision of local services including water; • regulation of land use; • powers of taxation; • expropriation of land; and • other measures necessary to ensure the orderly conduct of business. For example, in some areas local by-laws require that adequate supplies of groundwater are available before subdivisions are allowed to proceed. The Act also stipulates that when community plans are initiated they must include information pertaining to restrictions on the use of land that is environmentally sensitive; that development permits may designate areas for the protection of the environment; and that a development permit may require that no septic tank, drainage and deposit fields be constructed in area that the permit designates as containing water which is subject to degradation.
Local Services Act Ministry of Municipal Affairs	The Subdivision Regulation of this Act regulates minimum lot sizes for subdivision. These minimum lot sizes are set to consider assimilative waste capacity of on-site sewage systems and the proximity to water sources. The lot size is standard and does not consider geologic and geographic conditions of the site. Minimum lot sizes in highly vulnerable areas may need to be larger in order to effectively address environmental issues such as contamination of wells by a high density of sewage disposal fields in the area.
Growth Strategies Act Ministry of Municipal Affairs	This is enabling legislation and once a strategy has been developed, implementation agreements may become enforceable by law. The Ministry of Environment, Lands and Parks has developed "provincial interest statements" for consideration in the development of regional growth strategies. Only under special circumstances will the Minister (of Municipal Affairs) require the development of a growth strategy. A local authority involved in the process that disagrees with parts of the strategy will not be required to adhere to those provisions. Growth in a region can be planned to minimize potential impacts on water supply or quality.
Mines Act Ministry of Energy and Mines	As a part of the permit application under the Act, the proponent must outline a program for the protection and reclamation of land, watercourses and groundwater affected by the mine. As a condition of a permit, the proponent may be required to provide protection and mitigation of watercourses affected by the mine.
Mines Act – Health Safety and Reclamation Code for Mines Minerals Exploration Code Ministry of Energy and Mines	There are powers under this Act to make regulations respecting standards for environmental protection and reclamation. One of the aims of the Code for Mines is to protect and reclaim the land and watercourses affected by mining. Plans for coal and hardrock mineral mines must contain particulars with respect to the protection of watercourses, including prediction of effluent quality for activities and drainage control, monitoring and maintenance. During the construction and operation phases of mining, a program must be developed to ensure that water quality is maintained, drainage is restored and use and productivity is returned. Mineral exploration at a designated site must take all the necessary steps to ensure that no drilling fluid, water, or drill cuttings contaminate any drinking or irrigation water supply.
Health Act Ministry of Health Regional Health Boards Community Health Services Societies	Empowers health officials to conduct the review, investigation, monitoring, regulation and control of waterworks systems, septic tanks, and sewage disposal systems for the purposes of health protection. The Act also contains provisions that require owners of land, whose land or land-use practices are believed to have caused a health hazard, to cease activities causing the hazard. The Sanitary Regulations specify minimum distances between wells and potential sources of contamination and require the proper closure of abandoned wells. The Safe Drinking Water Regulation requires: (1) a review of plans and specifications of any proposed works supplying more than one single family residence, and of a water quality analysis, prior to issue of a construction permit; (2) that every person operating a waterworks system hold a valid operating permit for that system; (3) the purveyor to disinfect all surface water and provide potable water to all users; and (4) notification to all users in the event of a health hazard. The Sewage Disposal Regulations requires every person constructing, installing, altering or repairing a sewage disposal system (which includes a septic tank), or a person using, operating or covering a sewage disposal system, to have a permit and to comply with its conditions. The Sanitary Regulation prohibits contamination of drinking water sources and is applied in some regions although its application is often limited due to its age (developed circa 1917). The Safe Drinking Water Regulation sets microbiological standards for fecal and total coliform only. There is no specific reference to other water quality criteria such as standards for inorganic substances. Only water supplied by a purveyor is subject to the regulation.

TABLE 4.1 EXISTING PROVINCIAL LEGISLATION (CURRENT AS OF 1999)

Legislation (Lead Agency)	Description
Municipal Act Ministry of Municipal Affairs	The Act allows for the - organization of municipalities, improvement districts, regional districts; - provision of local services including water; - regulation of land use; - powers of taxation; - expropriation of land; and - other measures necessary to ensure the orderly conduct of business. For example, in some areas local by-laws require that adequate supplies of groundwater are available before subdivisions are allowed to proceed. The Act also stipulates that when community plans are initiated they must include information pertaining to restrictions on the use of land that is environmentally sensitive; that development permits may designate areas for the protection of the environment; and that a development permit may require that no septic tanks, drainage and deposit fields be constructed in area that the permit designates as containing water which is subject to degradation.
Local Services Act Ministry of Municipal Affairs	The Subdivision Regulation of this Act regulates minimum lot sizes for subdivision. These minimum lot sizes are set to consider assimilative waste capacity of on-site sewage systems and the proximity to water sources. The lot size is standard and does not consider geologic and geographic conditions of the site. Minimum lot sizes in highly vulnerable areas may need to be larger in order to effectively address environmental issues such as contamination of wells by a high density of sewage disposal fields in the area.
Growth Strategies Act Ministry of Municipal Affairs	This is enabling legislation and once a strategy has been developed, implementation agreements may become enforceable by law. The Ministry of Environment, Lands and Parks has developed "provincial interest statements" for consideration in the development of regional growth strategies. Only under special circumstances will the Minister (of Municipal Affairs) require the development of a growth strategy. A local authority involved in the process that disagrees with parts of the strategy will not be required to adhere to those provisions. Growth in a region can be planned to minimize potential impacts on water supply or quality.
Mines Act Ministry of Energy and Mines	As a part of the permit application under the Act, the proponent must outline a program for the protection and reclamation of land, watercourses and groundwater affected by the mine. As a condition of a permit, the proponent may be required to provide protection and mitigation of watercourses affected by the mine.
Mines Act – Health Safety and Reclamation Code for Mines Minerals Exploration Code Ministry of Energy and Mines	There are powers under this Act to make regulations respecting standards for environmental protection and reclamation. One of the aims of the Code for Mines is to protect and reclaim the land and watercourses affected by mining. Plans for coal and hardrock mineral mines must contain particulars with respect to the protection of watercourses, including prediction of effluent quality for activities and drainage control, monitoring and maintenance. During the construction and operation phases of mining, a program must be developed to ensure that water quality is maintained, drainage is restored and use and productivity is returned. Mineral exploration at a designated site must take all the necessary steps to ensure that no drilling fluid, water, or drill cuttings contaminate any drinking or irrigation water supply.
Health Act Ministry of Health Regional Health Boards Community Health Services Societies	Empowers health officials to conduct the review, investigation, monitoring, regulation and control of waterworks systems, septic tanks, and sewage disposal systems for the purposes of health protection. The Act also contains provisions that require owners of land, whose land or land-use practices are believed to have caused a health hazard, to cease activities causing the hazard. The Sanitary Regulations specify minimum distances between wells and potential sources of contamination and require the proper closure of abandoned wells. The Safe Drinking Water Regulation requires: (1) a review of plans and specifications of any proposed works supplying more than one single family residence, and of a water quality analysis, prior to issue of a construction permit; (2) that every person operating a waterworks system hold a valid operating permit for that system; (3) the purveyor to disinfect all surface water and provide potable water to all users; and (4) notification to all users in the event of a health hazard. The Sewage Disposal Regulations requires every person constructing, installing, altering or repairing a sewage disposal system (which includes a septic tank), or a person using, operating or covering a sewage disposal system, to have a permit and to comply with its conditions. The Sanitary Regulation prohibits contamination of drinking water sources and is applied in some regions although its application is often limited due to its age (developed circa 1917). The Safe Drinking Water Regulation sets microbiological standards for fecal and total coliform only. There is no specific reference to other water quality criteria such as standards for inorganic substances. Only water supplied by a purveyor is subject to the regulation.

TABLE 4.1 EXISTING PROVINCIAL LEGISLATION CONTINUED

Legislation (Lead Agency)	**Description**
Waste Management Act Ministry of Environment, Lands and Parks	While the *Waste Management Act* is not limited to managing and regulating point-source pollution, the Act is usually only applied to point source pollution management because it so difficult to attribute non-point source pollution to a particular source or polluter. The Act regulates activities that introduce wastes into the environment, store special waste or treat or recycle special waste. It includes various regulations related to the disposal or other handling of waste products from industrial or other processes. Special Waste Regulations control the storage and discharge of special wastes into the ground and ground water.
Environmental Management Act Ministry of Environment, Lands and Parks	This Act is very high level and has been applied mainly to emergency situations. In general, other tools are used to protect the environment. Enables the Minster of Environment to require Environmental Impact Assessments for any activities that may have an adverse environment impact. The Act also enables the Minister to prepare environmental management plans for specific areas of the province and mandates Environmental Protection Orders that can be used to delay or stop activities which could have negative environmental consequences. The Act also authorizes the Minister to declare environmental emergency measures that can be invoked in the case of an environmental emergency such as a major chemical spill.
Environmental Assessment Act Ministry of Environment, Lands and Parks	Requires an environmental assessment to be prepared for major water storage and diversion projects including groundwater extractions which exceed 75 litres per second (approx. 1,000 Igal per minute). Any use of groundwater above this extraction rate requires an environmental study to assess any potential impacts on neighbouring wells or other source of water. Proper closure practices also have to be followed for any existing wells of this capacity that are abandoned.
Pesticide Control Act Ministry of Environment, Lands and Parks	Requires every person applying pesticide to a body of water or an area of public land to have a permit and to comply with its terms (The Act does not apply to pesticides applied on private land used for grazing and/or farming). The Act also provides that pesticides must be stored, transported and disposed of in a manner specified by regulations and allows for seizure of a pesticide, equipment and records, and other enforcement measures. Note: Not all pesticide use and pesticides require a permit
Agricultural Waste Control Regulation, Ministry of Environment, Lands and Parks	Prescribes practices for using, storing and managing agricultural waste in an environmentally sound manner and provides exemptions from permitting requirements under the *Waste Management Act* for farmers who adhere to the Code.
Environment and Land Use Act Ministry of Environment, Lands and Parks	Empowers the Environment and Land Use Committee to make recommendations to the Lieutenant Governor-in-Council with respect to preservation and maintenance of the natural environment in the administration of land use and resource development. The Lieutenant Governor-in-Council may make such orders respecting the environment or land use as advisable.
Water Protection Act Ministry of Environment, Lands and Parks	This Act reconfirms that groundwater is a public resource and restricts bulk removal of groundwater for export purposes.
Fish Protection Act Ministry of Environment, Lands and Parks	This Act enables water management area designation and planning and allows government to take a broad planning approach when managing water issues, including groundwater, in critical areas of the province. The planning provisions under this Act are limited due to the lack of specific regulatory tools for groundwater management available for use during planning and implementation of water management areas.
Water Act Ministry of Environment, Lands and Parks	This Act enables the Ministry of Environment, Lands and Parks to issue water licences for use of surface water and spring sources and to regulate work in and around a stream. This Act does not currently allow for licensing of wells.

TABLE 4.2 SUMMARY OF NON-REGULATORY TOOLS FOR GROUNDWATER PROTECTION

Non-Regulatory Tool	Description
Land acquisition by the community	Purchase, exchange or donate land to control land use over the aquifer. Effective in rural areas where there is little existing development and for local problems. Not practical in more developed areas or where large areas of land are needed to protect the aquifer. On-going management, maintenance, and loss of tax base are also considerations.
Purchase of development rights	Purchasing the right to develop a parcel of land while keeping the property under private ownership. Property owner is paid the difference between the current value and development value of their land; in effect, paying the landowner not to develop. Effectiveness of this option is similar to land acquisition, except that it is likely less costly. Useful where regulatory restrictions on land use are not politically feasible and the purchase of the development rights is affordable.
Conservation easements	A voluntary, legal agreement that the property owner makes with the local government to limit the type and degree of development on their property. Less costly than land acquisition but depends on the goodwill of the property owner.
Covenants	A covenant is a formal and binding written contract between the landowner and another party (such as the municipality). The covenant restricts the use of the land. It is registered against the title of a property and is binding on future landowners. Refer to the *Land Titles Act*, Section 219.
Market approaches	Use taxes, subsidies, penalties to influence land use and to encourage aquifer protection. For example, tax credits for retaining private land as open space above aquifer recharge areas and for use of land for development in less vulnerable areas. Depends on the voluntary will of individual property owners.
Cluster developments	Promoting concentrated development in less vulnerable areas outside of groundwater protection zones.
Hazardous waste collection	Dispose of household hazardous waste at drop-off centres and/or to mobile collection units. In B.C. dispose of household paints, solvents and fuels at regional drop-off centres; contact the Recycling Hotline (1-800-667-4321) for information on your area. Depends on initiative of individual household. Public information/education is important.
Facility siting, design, and operation controls	Siting high impact activities/facilities away from vulnerable areas, incorporating environmental safeguards and controls. Usually regulated through zoning by-laws. For potential point sources of contamination. Examples of facilities that may require control are airports, auto repair shops, dry cleaners, gasoline stations and fuel storage facilities, laboratories, landfills, manufacturing and processing facilities, waste treatment and storage facilities.
Performance and operating standards	Establish measurable environmental standards that protect human health or the environment. Performance and operating standards alone do not specify how performance should be achieved. This approach provides more flexibility than design standards and Best Management Practices since almost any method can be used as long as the performance standard is achieved. To be effective, performance and operation standards must be implemented far enough from a well head area that non-compliance can be rectified without posing a threat to the well.
Storm water and sewage controls	Collecting and directing storm water and sewage away from vulnerable areas and treating the discharge. This involves regular maintenance, inspections, and up-grades (non-regulatory) as well as registration, permitting, and testing of these systems (regulatory).
Water conservation	Encourage individuals, commercial and industrial users to limit their water use, thereby reducing demand on groundwater supplies. Useful in coastal areas where saltwater encroachment is a possibility.
Technical assistance for Best Management Practices	Provide technical advice for evaluating, developing, implementing and monitoring Best Management Practices (BMPs), agricultural wastes, animal wastes, industry practices, commercial operations, Integrated Pest Management (IPM) etc.
Well construction guidelines	Specifies how drillers and well owners can properly construct, maintain and abandon wells according to guidelines to minimize local water quality degradation in the protection area from poor well construction practices.
Voluntary certification of well drillers and pump installers	Certification requirements for well drillers and well pump installers ensure that wells are constructed, tested and equipped to an acceptable standard of workmanship and environment safeguards are met. Promotes use of certified well drillers and pump installers.
Public Education	Raise public awareness and communicate the well protection message to others by using newsletters, brochures, posters, signage, presentations, talks, and other communication tools.

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APPENDIX 4.2 SAMPLE TABLE OF CONTENTS FOR A WELL PROTECTION PLAN

Section	Contents	Comments
Executive Summary	A concise summary of the main points of the plan	Write this last!
Introduction	Brief description and relevant history of the community Description of the community water supply Background on water quality issues Reasons for protecting the well supply	
STEP ONE The Community Planning Team	Terms of reference for planning team Members of the planning team Goals and objectives	Acknowledge those who helped Describe process followed Explain what a well protection plan is and why your community has prepared one
STEP TWO The Well Protection Area	Description of the aquifer and hydrogeology (vulnerable and non-vulnerable areas) Capture zone (location, how it was defined, uncertainties) Time of travel areas Map of well protection area	Note any implications for protection (e.g. protection area is in private ownership) Note any missing information, and how it will be gathered
STEP THREE Sources of Potential Contamination	Describe contaminant inventory and surveys Explain results List priorities Map of sources and priorities Describe how data is stored	Describe what the potential sources are, where they are, and level of priority Note plans for updating the inventory
STEP FOUR Management Options	Describe range of possible management options (and how derived) Show results of S*M*A*R*T test Describe results of public consultation/information Describe final list of management activities selected Implementation schedule (who will implement actions, how and when) Identify indicators that will be used to measure success	List all the results of the S*M*A*R*T test and describe why options passed or failed Describe how sources will be managed
STEP FIVE Contingency Plan	List all possible contamination events Identify resources available to deal with emergencies Describe contingency plans	Describe what to do in case the water supply is impaired and how to deal with this (short-term and long-term)
STEP SIX Evaluating the Plan	Describe how water quality will be monitored Describe how the well protection plan will be monitored and evaluated (who, how often)	Identify success measures
Appendices	Include any detailed information E.g. data for contaminant survey, results of public meetings, calculation of well capture zone delineation	

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Appendices	Include any detailed information E.g. data for contaminant survey, results of public meetings, calculation of well capture zone delineation	

STEP FOUR:
Potential Management Options

List Management Options and Apply S*M*A*R*T Test

A public meeting was held at the fire-hall to present the survey findings. Planning team leader Andrew Aiken chaired the meeting. The meeting was attended by a number of residents, members of the community planning team, and the students and teachers involved in the mapping exercise. About 30 people spent the evening discussing and identifying possible management options for every potential contaminant source (Table CS 4.1), and listing the agencies with the authority to control activities. The participants then applied the S*M*A*R*T test to assess the suitability of each possible option (Table CS 4.2).

The idea of protecting groundwater was new to the community, and although they were supportive, they were somewhat cautious and concerned about cost implications. The planning team agreed it would be best to focus first on non-regulatory options, by educating landowners and stakeholders about ways to change land use practices. For many of the options, the next step for the planning team will be to talk to the owner/operator and get their commitment to implement the option.

The support of the various provincial agencies and the Regional District is vital to the success of both regulatory and non-regulatory measures. Members of the planning team made sure that local staff from both levels of government (provincial and regional) knew about and supported the well protection initiative.

Identify Non-Regulatory Measures

Simon Lee, the farmer of A-4 and A-5, is part of the planning team and is already implementing Best Management Practices (BMP) and Integrated Pest Management (IPM) on his property. His support of groundwater protection activities is a key to Pumphandle's success in developing the plan. He has also indicated a willingness to speak to the other farmers in the area on BMPs and IPMs.

The proximity of the gas station and dry cleaner to Aiken's Well was a real concern to the community because this is the only water supply for 500 residents. There was considerable discussion about the possibility of relocating these activities outside of the well protection area. However, without legislated authority, the planning team agreed to encourage the owners of these facilities to adopt Best Management Practices instead. The concerns were lessened somewhat when the purveyors proposed that the Blackwater Well become the main source of supply in the near future.

Actions for the coming year would include:

- The farmer and purveyors would meet with the other farmers and the golf course operators to encourage them to adopt BMPs and IPMs that would minimize use of pesticides and fertilizers;
- The Environmental Health Officer would ask the owner of A-3 to grout his abandoned well to prevent contaminants from directly entering into the aquifer;
- The Environmental Health Officer would work with the owners of the gas station and dry cleaner to attend a spill response course and adopt improved practices;
- The Pumphandle Valley Conservation Society would distribute information to encourage key landowner/operators to adopt groundwater-friendly practices;[6]
- The Regional District would place signs on the roads, letting people know that they are entering a well protection area; and
- The Regional District would develop a public education program. They would work with the

[6] E.g. Ministry of Agriculture, Fisheries and Food, 1977. *Environmental Guidelines for Poultry Producers in British Columbia.* Published in cooperation with the Poultry Industry of B.C. and the B.C. Federation of Agriculture. See also, Ministry of Agriculture, Fisheries and Food 1995. *Environmental Guidelines for Berry Producers in British Columbia.* Environment Canada and Province of British Columbia.

Pumphandle Valley Conservation Society and purveyors to prepare a two-page newsletter on wise use of garden fertilizers and pesticides, to be sent with the water bills to all residents in the region.

Identify Regulatory Measures

Under provincial legislation, the Agricultural Code of Practice is the main regulatory control. Staff from the local Ministry of Environment, Lands and Parks agreed to place a priority on enforcing the Agricultural Code of Practice over the entire aquifer in the Pumphandle Valley, including the handling of manure and other agricultural waste for the poultry barn on A-3 and on the other farms.

The Regional District agreed to create new by-laws to require private and community septic systems to be maintained on a regular three-year basis, and to restrict the quantity of dry cleaning chemicals in the protection area. They will also work towards a third by-law, that would require that any new land development in the well protection area to identify and address potential impacts on the groundwater.

No changes to local land use zoning were proposed but impacts on groundwater would be considered when the zoning plan is next reviewed in two years' time. Signs and fencing around the gravel pit (I-1), where illegal dumping may occur, could become a condition of the permit for that operation. The Regional Engineer would contact the Mines Inspector for support of this proposal.

Prepare an Action Plan and Schedule

The planning team reviewed all of the management options that passed the S*M*A*R*T test and decided that all the options are worth implementing. They drew up a two-year schedule for implementing the management options (Table CS 4.3). The focus will be on encouraging landowners to adopt the recommended practices within the first year.

TABLE CS 4.1: POSSIBLE MANAGEMENT OPTIONS FOR EACH POTENTIAL SOURCE

Source Activity	Potential Sources of Contaminants	Jurisdiction	Possible Management Options
*A-1-hay field	Fertilizers	MAF[7]	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Blackwater Well, monitor for nitrate-N
+A-2-hay field former corn field	Fertilizers Atrazine	MAF	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Charlie's Well, monitor for nitrate-N and pesticides
+A-3-hay field + barn	Abandoned well Poultry wastes Fertilizers	MAF MOH	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Blackwater Well and Aiken's Well, monitor for nitrate-N, convince owner to decommission abandoned well (MOH-*Health Act*)
+A-4 hay field	Fertilizers	MAF	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Blackwater Well, monitor for nitrate-N
*A-5-corn field	Pesticides, fertilizers	MAF	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Aiken's Well & Blackwater Well, monitor for nitrate-N
+A-6-corn field	Pesticides, fertilizers	MAF	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Aiken's Well & Blackwater Well, monitor for nitrate-N
*C-1-gas station	Gasoline, septic system, oils, chemicals	MELP[8]	Test tanks for leaks, replace tanks & install leak detection system, educate operator, monitor for VOCs[9], relocate gas station outside of capture zone
*C-4-dry cleaner	Perchloroethylene (perc)	MELP Regional District	Adopt CCME[10] Code of Practice, encourage owner to take spill response course, educate owner to join industry association, pass by-law to restrict amount of perc in capture zone, relocate dry cleaner outside of capture zone
+C-2-hotel	Septic system	MOH[11]	Maintain septic system, build piped sewer system
*C-3-private golf course	Pesticides, fertilizers, septic system	MOH (for septic systems only)	Review nitrate-N results and sample for nitrate-N, provide lawn care & integrated pest management educational material to owners, Best Management Practices for golf course, maintain septic systems, build piped sewer system
+I-1-gravel pit	Illegal dumping	MEM[12]	Put signage up, restricted access (fencing), review permit, note any future land use changes, waste disposal education
*R-1-subdivision	Pesticides, fertilizers, septic system, degreasers, household hazardous wastes	MOH; MELP	Signage, educate residents on waste disposal, pesticide usage, water conservation, maintain septic system or build piped sewer system, distribute newsletter, review and monitor for nitrate-N in Aiken's Well
*R-2-subdivision and campground	Pesticides, fertilizers, septic system, degreasers, household hazardous wastes	MOH; MELP	Signage, educate residents on waste disposal, pesticide usage, water conservation, septicsystem maintenance, produce and distribute newsletter, review and monitor for nitrate-N in Charlie's Well.
+R-3-subdivision	Pesticides, fertilizers, septic system, degreasers, household hazardous wastes	MOH; MELP	Signage, educate residents on waste disposal, pesticide usage, water conservation, septic system maintenance, produce and distribute newsletter, review and monitor for nitrate-N in Charlie's Well.
*T-1-main road	Chemicals, garbage, salt	Regional District	Signage, prepare an emergency spill response plan, initiate a road keepers program ("adopt a road"), ensure main road is not used to transport dangerous goods.

Source activity coding: C= commercial, I= industrial, A = agricultural, R=residential, T= transportation

Priority Coding: * = 1st priority + = 2nd priority

[7] MAF: Ministry of Agriculture and Food, [8] MELP: Ministry of Environment, lands and Parks, [9] VOCs: Volatile Organic Compounds,

[10] CCME: Canadian Council of Ministers of the Environment, [11] MOH: Minitry of Health, [12] MEM: Ministry of Energy and Mines

TABLE CS 4.1: POSSIBLE MANAGEMENT OPTIONS FOR EACH POTENTIAL SOURCE

Source Activity	Potential Sources of Contaminants	Jurisdiction	Possible Management Options
*A-1-hay field	Fertilizers	MAF[7]	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Blackwater Well, monitor for nitrate-N
+A-2-hay field former corn field	Fertilizers Atrazine	MAF	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Charlie's Well, monitor for nitrate-N and pesticides
+A-3-hay field + barn	Abandoned well Poultry wastes Fertilizers	MAF MOH	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Blackwater Well and Aiken's Well, monitor for nitrate-N, convince owner to decommission abandoned well (MOH-*Health Act*)
+A-4 hay field	Fertilizers	MAF	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Blackwater Well, monitor for nitrate-N
*A-5-corn field	Pesticides, fertilizers	MAF	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Aiken's Well & Blackwater Well, monitor for nitrate-N
+A-6-corn field	Pesticides, fertilizers	MAF	Best Management Practices (MAF), educate farmer, review historical nitrate-N values for Aiken's Well & Blackwater Well, monitor for nitrate-N
*C-1-gas station	Gasoline, septic system, oils, chemicals	MELP[8]	Test tanks for leaks, replace tanks & install leak detection system, educate operator, monitor for VOCs[9], relocate gas station outside of capture zone
*C-4-dry cleaner	Perchloroethylene (perc)	MELP Regional District	Adopt CCME[10] Code of Practice, encourage owner to take spill response course, educate owner to join industry association, pass by-law to restrict amount of perc in capture zone, relocate dry cleaner outside of capture zone
+C-2-hotel	Septic system	MOH[11]	Maintain septic system, build piped sewer system
*C-3-private golf course	Pesticides, fertilizers, septic system	MOH (for septic systems only)	Review nitrate-N results and sample for nitrate-N, provide lawn care & integrated pest management educational material to owners, Best Management Practices for golf course, maintain septic systems, build piped sewer system
+I-1-gravel pit	Illegal dumping	MEM[12]	Put signage up, restricted access (fencing), review permit, note any future land use changes, waste disposal education
*R-1-subdivision	Pesticides, fertilizers, septic system, degreasers, household hazardous wastes	MOH; MELP	Signage, educate residents on waste disposal, pesticide usage, water conservation, maintain septic system or build piped sewer system, distribute newsletter, review and monitor for nitrate-N in Aiken's Well
*R-2-subdivision and campground	Pesticides, fertilizers, septic system, degreasers, household hazardous wastes	MOH; MELP	Signage, educate residents on waste disposal, pesticide usage, water conservation, septicsystem maintenance, produce and distribute newsletter, review and monitor for nitrate-N in Charlie's Well.
+R-3-subdivision	Pesticides, fertilizers, septic system, degreasers, household hazardous wastes	MOH; MELP	Signage, educate residents on waste disposal, pesticide usage, water conservation, septic system maintenance, produce and distribute newsletter, review and monitor for nitrate-N in Charlie's Well.
*T-1-main road	Chemicals, garbage, salt	Regional District	Signage, prepare an emergency spill response plan, initiate a road keepers program ("adopt a road"), ensure main road is not used to transport dangerous goods.

Source activity coding: C= commercial, I= industrial, A = agricultural, R= residential, T= transportation

Priority Coding: * = 1st priority + = 2nd priority

[7] MAF: Ministry of Agriculture and Food, [8] MELP: Ministry of Environment, Lands and Parks, [9] VOCs: Volatile Organic Compounds,

[10] CCME: Canadian Council of Ministers of the Environment, [11] MOH: Ministry of Health, [12] MEM: Ministry of Energy and Mines

TABLE CS 4.2: SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
1 A-1 to 4 hay fields (does not address historic corn field at A2)	Encourage growers to optimize fertilizer use & implement Best Management Practices (BMPs)	Specify BMPs for fertilizer & irrigation	Record fertilizer & water use; measure crop yield	Farmer on CPT[13] is already implementing BMP at A-4	Consult MAF[14] & AC[15] on BMP	Farmer on CPT and purveyor to talk to growers at A-1, 2, & 3; implement BMPs by next year	Pass
2a. A-5, 6 corn fields	Encourage growers to optimize fertilizer use & implement BMP to reduce nitrate loading	See 1	See 1	Landowner at A-5 on CPT & is already implementing BMP	Consult MAF's environmental guidelines on field corn production	Farmer on CPT and purveyor to talk to grower at A-6; implement BMP within 2 years for A-6	Pass
2b.	Encourage growers to reduce pesticide use with IPM plan	Identify alternative pest control methods, develop IPM & implement	Reduced pesticide use; regular inspections	Technical assistance available from consultants	Consult MAF & hire pest management consultants	Farmer on CPT and purveyor to talk to grower at A-6; implement IPM by next year for A-5 & within 2 years for A-6	Pass
3a. A-7 raspberry field	Encourage growers to optimize fertilizer use & implement BMP	See 1	See 1	Landowner at A-7 was cooperative during inventory survey in Step 3	Consult MAF's environmental guidelines on berry production	Farmer on CPT and purveyor to talk to grower at A-7; implement BMP within 2 years	Pass
3b.	Encourage growers to reduce pesticide use by implementing IPM plan	See 2b	See 2b	See 2b	See 2b	As above	Pass
4a. A-3 poultry barn	Handle & dispose of manure in accordance with MELP's Code of Practice	Landowner implements Code of Practice	Periodic inspections	MELP[16] to enforce regulation	Code of Practice is regulation	Already being done; MELP to begin inspections by next year	Pass
4b.	Grower to dispose of carcasses to compost facility in accordance with MELP's Code of Practice	Temporarily hold carcasses in freezer container & regularly dispose at compost facility	Records at compost facility; periodic inspection	Nominal cost for disposal	Done elsewhere	Implement next year	Pass
5a. C-3 private golf course	Encourage owner to minimize herbicide & pesticide use through IPM plan	Develop IPM for herbicide & pesticide use & implement	Reduced quantity of herbicide & pesticide use; regular inspections	Greens can be maintained using eco-friendly maintenance techniques, training of grounds keepers required	Consult DFO[17] & EC[18] guidelines & industry association forBMP (e.g. Canadian Golf Superintendent Association)	Farmer on CPT and purveyor to talk to the golf course owner at C-3; implement within 2 years	Pass
5b.	Encourage owner to minimize fertilizer use & implement BMP	See 1	Reduced fertilizer & water use; periodic inspections	As above	As above	As above	Pass

TABLE CS 4.2: SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
5c.	Encourage owner to maintain septic system	Annual maintenance of septic system by owner	Septic system maintenance records	Reasonable cost (<$500)	Routinely done elsewhere	Implement by next year	Pass
5d.	Pass by-law to require regular maintenance of septic system	Create by-law to require owners in capture zone to maintain septic system annually	Maintenance records	<$200 for household system; <$500 for community system	As above (example draft by-law available from other municipalities)	Make proposal to Regional District planner; pass by-law within 2 years	Pass
6a. R-1-3 trailer park & subdivision	Include 2-page newsletter in water bill about wise use of garden fertilizers & pesticides, disposal of household hazardous waste, & water conservation	CPT produce one newsletter & mail to clients	One newsletter produced & distributed	Pumphandle Valley Conservation Society and the purveyors designs newsletter & Regional District pays for copying; advice on content from MELP & Regional District	Done in other municipalities	Implement immediately & send out in next water & pad rental bills; repeat on annual basis with up-dates & articles	Pass
6b.	Organize hazardous waste collection annually (paints, solvents/flammable liquid/pesticides)	Collect household paints & solvents; include information in two-page newsletter	Ship household wastes to depots once a year	Paint depot in Chilliwack; solvent depot to be established by 1998; call depot to set-up drop-off	Call B.C. Recycling Hotline or Paint Care Association (604-482-8686) for more information	CPT to organize collection annually	Pass
6c.	Encourage owners to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
6d.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5d	See 5c	See 5d	Pass
7a. hotel	Encourage owner to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
7b.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5d	See 5c	See 5d	Pass
8a. abandoned well	Grout well in accordance with MELP's draft Code of Practice	Hire driller to grout & cap well	Well capped & grouted; driller's records	Cost ~$1K	Common industry practice	EHO to talk to owner of A-3; obtain well construction record; hire driller by Fall	Pass
9a. I-1 gravel pit	Erect signs, "*No Dumping in Gravel Pit*" along the fence	Produce & erect signs (by owner)	Signs produced & erected by pit staff	$50/sign	Pit staff to do this on slow days	Regional Engineer to talk to pit owner/operator at I-1 & MEM's[19] District Manager; have sign erected by Fall	Pass

TABLE CS 4.2: SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
1 A-1 to 4 hay fields (does not address historic corn field at A2)	Encourage growers to optimize fertilizer use & implement Best Management Practices (BMPs)	Specify BMPs for fertilizer & irrigation	Record fertilizer & water use; measure crop yield	Farmer on CPT[13] is already implementing BMP at A-4	Consult MAF[14] & AC[15] on BMP	Farmer on CPT and purveyor to talk to growers at A-1, 2, & 3; implement BMPs by next year	Pass
2a. A-5, 6 corn fields	Encourage growers to optimize fertilizer use & implement BMP to reduce nitrate loading	See 1	See 1	Landowner at A-5 on CPT & is already implementing BMP	Consult MAF's environmental guidelines on field corn production	Farmer on CPT and purveyor to talk to grower at A-6; implement BMP within 2 years for A-6	Pass
2b.	Encourage growers to reduce pesticide use with IPM plan	Identify alternative pest control methods, develop IPM & implement	Reduced pesticide use; regular inspections	Technical assistance available from consultants	Consult MAF & hire pest management consultants	Farmer on CPT and purveyor to talk to grower at A-6; implement IPM by next year for A-5 & within 2 years for A-6	Pass
3a. A-7 raspberry field	Encourage growers to optimize fertilizer use & implement BMP	See 1	See 1	Landowner at A-7 was cooperative during inventory survey in Step 3	Consult MAF's environmental guidelines on berry production	Farmer on CPT and purveyor to talk to grower at A-7; implement BMP within 2 years	Pass
3b.	Encourage growers to reduce pesticide use by implementing IPM plan	See 2b	See 2b	See 2b	See 2b	As above	Pass
4a. A-3 poultry barn	Handle & dispose of manure in accordance with MELP's Code of Practice	Landowner implements Code of Practice	Periodic inspections	MELP[16] to enforce regulation	Code of Practice is regulation	Already being done; MELP to begin inspections by next year	Pass
4b.	Grower to dispose of carcasses to compost facility in accordance with MELP's Code of Practice	Temporarily hold carcasses in freezer container & regularly dispose at compost facility	Records at compost facility; periodic inspection	Nominal cost for disposal	Done elsewhere	Implement next year	Pass
5a. C-3 private golf course	Encourage owner to minimize herbicide & pesticide use through IPM plan	Develop IPM for herbicide & pesticide use & implement	Reduced quantity of herbicide & pesticide use; regular inspections	Greens can be maintained using eco-friendly maintenance techniques, training of grounds keepers required	Consult DFO[17] & EC[18] guidelines & industry association forBMP (e.g. Canadian Golf Superintendent Association)	Farmer on CPT and purveyor to talk to the golf course owner at C-3; implement within 2 years	Pass
5b.	Encourage owner to minimize fertilizer use & implement BMP	See 1	Reduced fertilizer & water use; periodic inspections	As above	As above	As above	Pass

TABLE CS 4.2: SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
5c.	Encourage owner to maintain septic system	Annual maintenance of septic system by owner	Septic system maintenance records	Reasonable cost (<$500)	Routinely done elsewhere	Implement by next year	Pass
5d.	Pass by-law to require regular maintenance of septic system	Create by-law to require owners in capture zone to maintain septic system annually	Maintenance records	<$200 for household system; <$500 for community system	As above (example draft by-law available from other municipalities)	Make proposal to Regional District planner; pass by-law within 2 years	Pass
6a. R-1-3 trailer park & subdivision	Include 2-page newsletter in water bill about wise use of garden fertilizers & pesticides,disposal of household hazardous waste,& water conservation	CPT produce one newsletter & mail to clients	One newsletter produced & distributed	Pumphandle Valley Conservation Society and the purveyors designs newsletter & Regional District pays for copying; advice on content from MELP & Regional District	Done in other municipalities	Implement immediately & send out in next water & pad rental bills; repeat on annual basis with up-dates & articles	Pass
6b.	Organize hazardous waste collection annually (paints, solvents/flammable liquid/pesticides)	Collect household paints & solvents; include information in two-page newsletter	Ship household wastes to depots once a year	Paint depot in Chilliwack; solvent depot to be established by 1998; call depot to set-up drop-off	Call B.C. Recycling Hotline or Paint Care Association (604-482-8686) for more information	CPT to organize collection annually	Pass
6c.	Encourage owners to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
6d.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5d	See 5c	See 5d	Pass
7a. hotel	Encourage owner to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
7b.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5d	See 5c	See 5d	Pass
8a. abandoned well	Grout well in accordance with MELP's draft Code of Practice	Hire driller to grout & cap well	Well capped & grouted; driller's records	Cost ~$1K	Common industry practice	EHO to talk to owner of A-3; obtain well construction record; hire driller by Fall	Pass
9a. I-1 gravel pit	Erect signs, "*No Dumping in Gravel Pit*" along the fence	Produce & erect signs (by owner)	Signs produced & erected by pit staff	$50/sign	Pit staff to do this on slow days	Regional Engineer to talk to pit owner/operator at I-1 & MEM's[19] District Manager; have sign erected by Fall	Pass

TABLE CS 4.2: SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
9b.	Educate workers on handling, storing & disposing of petroleum products & spill response	Hang poster in pit office, staff take training & post emergency phone list in office	Poster hung, course taken & phone list posted	Order poster from MELP, have manager develop safety program and deliver to staff, & compile emergency phone list with CPT	Staff well aware of groundwater protection efforts	As above	Pass
10a. gas station	Test tanks for leaks & keep records on gas bought/sold	Annually test; volume bought/sold reviewed by operator	Annual report to CPT	Operator already tracking volume of gas in tank	Common practice	Continue; EHO to discuss with owner about testing tank annually until new tank is installed	Pass
10b.	Encourage owner to replace existing tanks with newer double-lined tanks & install monitors to detect any leaks	Install new tanks	New tank installed	Company considering as part of renovation for next year	Estimated cost for 50,000 L tank is $5-10,000	EHO to discuss with owner to consider	Pass
10c.	Encourage owner to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
10d.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5c	See 5d	See 5d	Pass
11a. dry cleaner[20]	Encourage owner to adopt CCME[21] Code of Practice for operation	Follow CCME guidelines	Periodic inspection	Guidelines developed with industry	Guidelines available	EHO to talk to owner; adopt Code of Practice in 1 year	Pass
11b.	Encourage owner to recycle perc[22]	Volume of perc traceable	Volune perc recycled	Recycled by distributor	Being done in Ontario	Set up recycling by next year	Pass
11c.	Encourage owner to take spill response course	Take course in Vancouver	Course certificate	$200-400 for course	Owner write off as business expense	Take course in Fall	Pass
11d.	Encourage owner to join industry association (e.g. B.C. Fabricare Association) & implement BMP	Join association	Membership list	$190 for annual membership (includes membership in International Fabricare Association)	Owner write off as business expense	Join within 1 year	Pass
11e.	Pass by-law to restrict the quantity of perc in the capture zone	Enact by-law	By-law passed	Regional District is interested	Present dry cleaner in close proximity to Aiken's and Charlie's Wells	CPT to make proposal to Regional District planner; have by-law within 2 years	Pass
12a. T-1 main road	Erect signs, "*Entering Groundwater Protection Area of Pumphandle, B.C. Please do not pollute. For more information, call 555-1234* on main road near trailer park (R3) & hay field (A1)	Produce & erect 2 signs	Sign erected; calls for nore information received	$300/sign	2 signs produced by local volunteer students & erected by Regional District	Talk to school & Regional District about project; implement by next year	Pass

TABLE CS 4.2: SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
12b.	Develop roadside display & put up at parking lot in front of gas station-dry cleaner	One display with map showing the aquifer & the well protection plan	One display put up; calls for more information received	As part of student project for road signs	~$1K	Erect display in May next year – in time for tourist season	Pass
12c.	Encourage Regional District to develop eco-friendly road maintenance program, including less use of herbicides & salt on road R/W	Identify eco-friendly alternatives for road maintenance & implement	Reduced use of chemicals	Practices elsewhere	Apply to 2 km of main road	Implement in 18 months	Pass

[13] CPT = Community planning team, [14] MAF = Ministry of Agriculture and Food, [15] AC= Agriculture Canada,
[16] MELP = Ministry of Environment, Lands and Parks, [17] DFO = Department of Fisheries and Oceans, [18] EC = Environment Canada
[19] MEM= Ministry of Energy and Mines, [20] Standards being developed by Environment Canada, [21] CCME = Canadian Council of the Ministers of the Environment, [22] perc = perchloroethylene, a solvent used in the dry cleaning industry

TABLE CS 4.2: SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
9b.	Educate workers on handling, storing & disposing of petroleum products & spill response	Hang poster in pit office, staff take training & post emergency phone list in office	Poster hung, course taken & phone list posted	Order poster from MELP, have manager develop safety program and deliver to staff, & compile emergency phone list with CPT	Staff well aware of groundwater protection efforts	As above	Pass
10a. gas station	Test tanks for leaks & keep records on gas bought/sold	Annually test; volume bought/ sold reviewed by operator	Annual report to CPT	Operator already tracking volume of gas in tank	Common practice	Continue; EHO to discuss with owner about testing tank annually until new tank is installed	Pass
10b.	Encourage owner to replace existing tanks with newer double-lined tanks & install monitors to detect any leaks	Install new tanks	New tank installed	Company considering as part of renovation for next year	Estimated cost for 50,000 L tank is $5-10,000	EHO to discuss with owner to consider	Pass
10c.	Encourage owner to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
10d.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5c	See 5d	See 5d	Pass
11a. dry cleaner[20]	Encourage owner to adopt CCME[21] Code of Practice for operation	Follow CCME guidelines	Periodic inspection	Guidelines developed with industry	Guidelines available	EHO to talk to owner; adopt Code of Practice in 1 year	Pass
11b.	Encourage owner to recycle perc[22]	Volume of perc traceable	Volume perc recycled	Recycled by distributor	Being done in Ontario	Set up recycling by next year	Pass
11c.	Encourage owner to take spill response course	Take course in Vancouver	Course certificate	$200-400 for course	Owner write off as business expense	Take course in Fall	Pass
11d.	Encourage owner to join industry association (e.g. B.C. Fabricare Association) & implement BMP	Join association	Membership list	$190 for annual membership (includes membership in International Fabricare Association)	Owner write off as business expense	Join within 1 year	Pass
11e.	Pass by-law to restrict the quantity of perc in the capture zone	Enact by-law	By-law passed	Regional District is interested	Present dry cleaner in close proximity to Aiken's and Charlie's Wells	CPT to make proposal to Regional District planner; have by-law within 2 years	Pass
12a. T-1 main road	Erect signs, "*Entering Groundwater Protection Area of Pumphandle, B.C.. Please do not pollute. For more information, call 555-1234* on main road near trailer park (R3) & hay field (A1)	Produce & erect 2 signs	Signs erected; calls for more information received	$300/sign	2 signs produced by local volunteer students & erected by Regional District	Talk to school & Regional District about project; implement by next year	Pass

TABLE CS 4.2: SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S•M•A•R•T test
12b.	**Develop roadside display & put up at parking lot in front of gas station-dry cleaner**	One display with map showing the aquifer & the well protection plan	**One display put up; calls for more information received**	As part of student project for road signs	**~$1K**	Erect display in May next year – in time for tourist season	Pass
12c.	**Encourage Regional District to develop eco-friendly road maintenance program, including less use of herbicides & salt on road R/W**	Identify eco-friendly alternatives for road maintenance & implement	**Reduced use of chemicals**	Practices elsewhere	**Apply to 2 km of main road**	Implement in 18 months	Pass

[13] CPT = Community planning team, [14] MAF = Ministry of Agriculture and Food, [15] AC= Agriculture Canada, [16] MELP = Ministry of Environment, Lands and Parks, [17] DFO = Department of Fisheries and Oceans, [18] EC = Environment Canada [19] MEM= Ministry of Energy and Mines, [20] Standards being developed by Environment Canada, [21] CCME = Canadian Council of the Ministers of the Environment, [22] perc = perchloroethylene, a solvent used in the dry cleaning industry

M121

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TABLE CS 4.3: PROPOSED SCHEDULE FOR IMPLEMENTING MANAGEMENT OPTIONS

Land Use Activity	1999 Summer	Fall	Winter	2000 Spring	Summer	Fall	Winter	2001 Spring
Hay fields (A-1 to A-4)	Talk to farmers about adopting BMPs	→	→	Implement BMPs	→	→	→	→
Corn fields (A-5, 6)	Talk to farmers about adopting BMPs & IPMs	→	→	→	→	→	→	Implement BMPs & IPMs
Raspberry field (A-7)	Talk to farmers about adopting BMPs & IPMs	→	→	→	→	→	→	Implement BMPs & IPMs
Poultry barn (A3)	Farmers to implement Code of Practice	Implement BMP for manure disposal		MELP begins inspection Implement BMP for carcass disposal	→	→	→	→
Golf course (C-3)	Talk to owner about maintaining septic system & implement BMPs & IPMs	→	→	Maintain septic system	→	→	→	Implement BMPs & IPMs →
Campground & subdivision (R-1 to R-3)	Develop & send out 2-page newsletter			Maintain septic system	→	→	→	→
Hotel (C-2)				Maintain septic system	→	→	→	→
Abandoned well (A-3)		Grout off well						
Gravel pit (I-1)		Erect signs & train staff in proper waste storage & disposal						
Gas station	Talk to owner about testing tanks & installing new tanks Take course in spill response	→ Take course in spill response	→	Maintain septic system	→	→	→	→
Dry cleaner	Talk to owner about taking spill response course	Take course in spill response	→	→	→	Join industry association Adopt Code of Practice	→	→
Main road (T-1)	Identify eco-friendly methods of road maintenance	→	→	Erect signs on main road	Implement road maintenance program	→	→	→
Septic System Maintenance By-Law	Draft by-law for consultation	Consultation	→	→	Present by-law to elected officials	→	→	→

TABLE CS 4.3: PROPOSED SCHEDULE FOR IMPLEMENTING MANAGEMENT OPTIONS CONTINUED

Land Use Activity	1999 Summer	Fall	Winter	2000 Spring	Summer	Fall	Winter	2001 Spring
Restricted Storage of Hazardous Chemicals By-Law	→	→	**Draft by-law for consultation**	→	→	→	**Present by-law to elected officials**	
Community Hazardous Waste Collection	**Develop Household Hazardous Wastes program**	→	→	Hold first Household Hazardous Wastes collection				
Public education	**Develop & send out 2-page newsletter**							

TABLE CS 4.3: PROPOSED SCHEDULE FOR IMPLEMENTING MANAGEMENT OPTIONS

Land Use Activity	1999 Summer	Fall	Winter	2000 Spring	Summer	Fall	Winter	2001 Spring
Hay fields (A-1 to A-4)	Talk to farmers about adopting BMPs	→	→	Implement BMPs	→	→	→	→
Corn fields (A-5, 6)	Talk to farmers about adopting BMPs & IPMs	→	→	→	→	→	→	Implement BMPs & IPMs
Raspberry field (A-7)	Talk to farmers about adopting BMPs & IPMs	→	→	→	→	→	→	Implement BMPs & IPMs
Poultry barn (A3)	Farmers to implement Code of Practice	Implement BMP for manure disposal		MELP begins inspection Implement BMP for carcass disposal	→	→	→	→
Golf course (C-3)	Talk to owner about maintaining septic system & implement BMPs & IPMs	→	→	Maintain septic system	→	→	→	Implement BMPs & IPMs →
Campground & subdivision (R-1 to R-3)	Develop & send out 2-page newsletter			Maintain septic system	→	→	→	→
Hotel (C-2)				Maintain septic system	→	→	→	→
Abandoned well (A-3)		Grout off well						
Gravel pit (I-1)		Erect signs & train staff in proper waste storage & disposal						
Gas station	Talk to owner about testing tanks & installing new tanks Take course in spill response	→ Take course in spill response	→	Maintain septic system	→	→	→	→
Dry cleaner	Talk to owner about taking spill response course	Take course in spill response	→	→	→	Join industry association Adopt Code of Practice	→	→
Main road (T-1)	Identify eco-friendly methods of road maintenance	→	→	Erect signs on main road	Implement road maintenance program	→	→	→
Septic System Maintenance By-Law	Draft by-law for consultation	Consultation	→	→	Present by-law to elected officials	→	→	→

TABLE CS 4.3: PROPOSED SCHEDULE FOR IMPLEMENTING MANAGEMENT OPTIONS CONTINUED

Land Use Activity	1999 Summer	Fall	Winter	2000 Spring	Summer	Fall	Winter	2001 Spring
Restricted Storage of Hazardous Chemicals By-Law	→	→	Draft by-law for consultation	→	→	→	Present by-law to elected officials	
Community Hazardous Waste Collection	**Develop Household Hazardous Wastes program**	→	→	Hold first Household Hazardous Wastes collection				
Public education	**Develop & send out 2-page newsletter**							

NOTES

Step Five

DEVELOP CONTINGENCY PLANS

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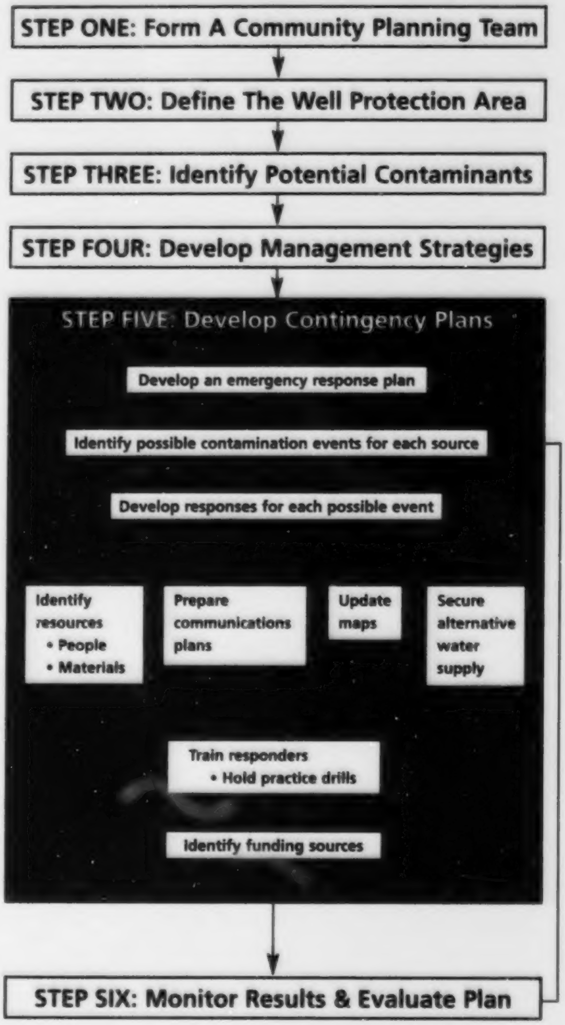
STEP ONE: Form A Community Planning Team
STEP TWO: Define The Well Protection Area
STEP THREE: Identify Potential Contaminants
STEP FOUR: Develop Management Strategies
STEP FIVE: Develop Contingency Plans
Develop an emergency response plan
Identify possible contamination events for each source
Develop responses for each possible event
Identify resources • People • Materials
Prepare communications plans
Update maps
Secure alternative water supply
Train responders • Hold practice drills
Identify funding sources
STEP SIX: Monitor Results & Evaluate Plan

More than 750,000 British Columbians rely on groundwater as their source of drinking water, and there are thousands of community well systems in British Columbia. A well protection plan allows communities to identify land use activities that may threaten the quality of their well water, and to develop a strategy to avoid or minimize these threats.

There are six steps to follow in developing a well protection plan:

1. Form a community planning team
2. Define the well protection area
3. Identify potential contaminants
4. Develop and implement management strategies
5. Develop contingency plans
6. Monitor results and evaluate the plan

These steps are described in the six booklets that make up the *Well Protection Toolkit*. Each booklet describes activities that lead to the development and implementation of a well protection plan. In each step, a fictional case study of the town of Pumphandle shows how one community took on this challenge.

Step Five: Develop Contingency Plans

The fifth step is the development of contingency plans that will allow the team to react quickly and appropriately to a contamination event. It involves preparing a plan of action to respond to all possibilities – from a major spill in the capture zone to minor spills close to the well. These contingency plans involve an emergency response and contingency component.

Emergency response procedures, which the Safe Drinking Water Regulation requires each water purveyor to prepare, typically consist of a set of standard operating procedures for handling different emergencies specific to the waterworks system. Contingency planning involves identifying the range of possible contamination events for each of the potential sources listed in Step Three, and developing a set of appropriate responses. This includes finding out who can respond to events and what materials they will need, and providing training and simulation exercises so that the team is ready to put plans into action. The planning team should also be ready to issue public drinking water advisories on short notice and to update maps to include necessary information. The contingency plan will also identify alternative water supplies in case of contamination.

Figure 5.1 shows the stages of Step Five.

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Develop Contingency Plans

OBJECTIVES

- To identify potential contamination events that could pollute the well supply
- To identify mitigation measures to minimize an event
- To identify appropriate responses to possible contamination events
- To identify and secure the resources, including funding available to respond to contingency needs
- To ensure information to support an emergency response is updated on maps and lists
- To identify and secure alternative sources of water in case of emergency
- To be prepared to issue public advisories at short notice

No matter how effectively you manage your well protection area, there is still a chance that an unforeseen event or accident may contaminate the water supply. Contamination can be very costly to clean up. In some cases, it may not be cost effective or even possible to clean up, and the well must be abandoned. Finding a new drinking water supply may not be an easy task.

Step Five includes dealing with emergency events that impact the water supply and contingency measures that ensure the community and the residents within the well protection area continue to receive potable water. Step Five includes both the emergency response procedures and contingency plans.

In many documents, the terms "emergency response plan" and "contingency plan" are used interchangeably. In British Columbia, water purveyors must prepare an emergency response plan as part of their regulatory responsibility under the Safe Drinking Water Regulation. In Step Five the water purveyor's emergency response plan is used as the foundation for building the contingency plan for the well protection area. The emergency response plans and the contingency plan are integrally related.

Examples of Emergencies

- Flood
- Earthquake
- Loss of source
- Spill or chemical contamination
- Sabotage
- Power outage
- Operator error
- Pump failure
- Broken water main
- Backflow conditions.

5.1 Prepare an Emergency Response Plan

The emergency response plan is a set of standard operating procedures that addresses a number of emergency situations that are specific to the waterworks systems. Each water purveyor has an emergency response plan, which covers situations that prevent them from supplying potable water to the community. This emergency response plan may already contain many of the necessary elements that could be in the contingency plan.

The Ministry of Health has prepared a booklet entitled *Emergency Response Planning for Small Water Systems*.[1] This booklet is designed to be used by smaller facilities, (e.g. trailer parks, campsites, motels, restaurants and mobile home facilities), however it is also a useful review document for operators of larger waterworks systems.

Find out about other emergency plans in your area. For example, does the chemical manufacturer have an emergency plan, or set of operating procedures in

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DISEASE OUTBREAK

During the winter of 1996/97, a sewer main broke approximately one hundred metres from two wells supplying drinking water to a small municipality in the southern interior of B.C.. Partially under snow cover, sewage travelled across the frozen ground to a point where it entered a gravel seam, which led directly to the aquifer from which the well was drawing its water.

The community water system became contaminated with an unidentified virus. A waterborne disease outbreak began on January 6th 1997. By January 19th, approximately 88% of the population became ill.

A well protection plan could have identified this potential emergency scenario and allowed for a more rapid response, and fewer health problems for the community.

case of a fire? Many facilities will already have emergency response plans, which you may choose to include in your plan. The team should work with these facilities to review and update their emergency response plans, so that they include procedures that minimize the impact on the groundwater. During the contaminant survey in Step Three, ask commercial and industrial operators if they have developed emergency plans.

The planning team should be prepared to respond to all likely contamination events. In developing an emergency response plan consider the following questions:

- What are the most likely and significant threats to local water supplies?
- What specific steps should be taken to address existing and/or potential threats?
- Who is responsible for each step in responding to emergencies, and how will response actions be coordinated?

Develop contingency measures:

- Where can temporary and permanent replacement water supplies be obtained if needed?
- Where can technical, logistical and financial resources be obtained?

When the emergency plan is completed, you will be prepared to:

- Respond appropriately to a contamination event. (Too often when a spill or other form of contamination occurs, the response is inappropriate – not enough is done, or too much is done and money is wasted);
- Protect the community from exposure to possible hazardous conditions involving a water supply;
- Avoid possible confusion during an emergency; and
- Provide alternative sources of water in case of water supply disruption due to contamination.

In some cases, you may require professional assistance to develop your emergency response plan.

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Start by listing all of the potential contaminants that were identified in Step Three. You can then develop a series of "what if..." scenarios for each one. For example, what if there is a spill from a chemical tanker within the one-year time of travel zone? What if you detect nitrates at your well, despite the protection measures implemented in Step Four?

Some events may be easy to predict (such as spills of known chemicals at a gas station), based on the information from Step Three. Other events will be less predictable, such as tanker trucks spilling an unknown chemical at any location in the capture zone.

The team should also consider natural disasters that could create an emergency within the well protection

EXAMPLE SCENARIOS

Scenario 1 - Chemical Spill: The community of Trafalgar has a flourishing industrial centre. Trafalgar's water supply is from three wells located within the city boundaries. The Trafalgar Well Protection Committee has listed hydrocarbons as the greatest potential threats to the drinking water supply. A release of these hydrocarbons into the groundwater could gradually lead to a contamination problem. Storage and transportation of these substances pose an additional risk to groundwater, including the possibility of a sudden, accidental release to the drinking water supply.

Response: In the case of a sudden release of hydrocarbons in the well protection area, the closest wells downhill from the spill will be isolated from the rest of the water supply system. Rationing will be imposed to limit the amount of water that is drawn toward the well field. The city will monitor water from the wells downhill from the spill. Water from the remaining wells will be used until contaminants appear in the monitored wells. If contaminants appear in the monitored wells at levels exceeding Canadian Guidelines for Drinking Water Quality, the remaining wells in the field will also be shut down. As soon as possible after the spill is detected, bottled water suppliers, neighbouring towns, owners of irrigation wells, and owners of water trucks will be contacted to confirm the availability of an alternative water supply. Arrangements were made as part of the contingency plan. If abandonment of the well field becomes necessary, Trafalgar will drill a new water supply well at Parker's Corners; a site purchased by the city a number of years ago "just-in-case". It is also important to communicate and work with other agencies during the clean-up effort and after, to monitor the effectiveness of the clean-up.

Scenario 2 - Traffic Accident & Spill: Highway 123 passes within 60m of Parker's Corners Well No. 3. The transportation of hazardous substances along this major north-south route poses the risk of major spills, which could threaten the safety of the drinking water supply.

Response: In the case of a spill in the well protection area, pumping at the well would cease. Parker's Corners Well No. 3 is the source of drinking water for the city; however, older municipal wells, in a different aquifer, supply the high school (Well No. 2) and the R.C.M.P. station and Parker's Corners Memorial Hospital (Well No. 1). While no longer connected to the distribution system, these wells could be used to supply the town in an emergency situation. The city engineer estimates that the wells could be connected to the distribution grid within four working days. Until the wells are connected to the system, residents would have to haul water from Well No. 1 or Well No.2.

The key elements of planning scenarios can be seen in these examples: a brief description of the event triggering a supply disruption, perhaps a few facts or other events that complicate matters, and a summary of the immediate water supply implications.

area. Those threats with a high probability are more likely to occur, while those with high severity will likely have a greater harmful effect on the water system. These potential threats are focused on the water system, and should be addressed in the water purveyor's emergency response plan. The planning team should discuss them in the larger context of the well protection area.

5.3 Develop Specific Responses to Each Scenario

Plan a response for the most likely events. You don't have to plan for every event but only those that are most likely to happen. Ask yourself:

- What types of material are needed for containing the spill and for clean-up?
- How far is the source from the well?
- How serious is the potential impact on the water supply? Are alternative sources of water required?

For example, if a chemical storage facility located inside the well protection area of a highly vulnerable aquifer burns or explodes, dowsing it with water may not be the best response, unless there is a reliable way to prevent the water from infiltrating into the aquifer. Procedures should be in place to implement a specific response to such an event at that location.

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TABLE 5.1 ROLES AND RESPONSIBILITIES

CONTACT:	RESPONSIBLE FOR:
Water Purveyor	First responder Supplying potable water Providing names of all employees and their responsibilities Emergency response plan Issue public water advisories
Community Planning Team	Providing names of all members, with a list of their roles in emergency situations
Medical Health Officer	Dealing with threats to public health including: Drinking water quality Contamination of drinking water supplies Chemical spills and effects on health Issuing public health advisories
Environmental Health Officer	Undertaking most of the Medical Health Officer's duties with respect to drinking water supplies Enforcing regulations under the *Health Act* Technical advice, drinking water quality and operation of septic systems
Public Health Engineer	Advising on water treatment Approving changes to waterworks system Providing assistance in responding to contamination events
Municipal Government Staff	First Responder Coordinating community-wide emergency plan? Issuing public water advisories
Police & Firefighter	First Responder Assist in coordinating community-wide emergency
Provincial Emergency Preparedness Program (PEP)	Could provide assistance in responding to major contamination events First Responder

The priorities set in Step Three will help determine the level of response necessary for a contamination event. Small spills, or spills of less toxic substances, may not jeopardize water quality and would not require a significant level of response. It is important that the nature of potential contaminants be identified before a spill occurs so that the response can be appropriate to the risk.

You should develop a full range of "what if?" scenarios, and standard operating procedures (SOPs), for events that are a high priority. However, if there are a large number of priority threats, it may not be necessary to list all of them in detail, as many emergencies will involve similar response procedures. If this is the case, make sure that you develop a variety of SOPs that would require use of different response, equipment, personnel, and procedures to allow development of different response approaches (see "Example Scenarios").

When the team defines potential "problem" scenarios, specific duties will be more clearly defined. It is important to assign responsibilities for each potential task to an individual during the planning process, rather than waiting until an emergency happens (Table 5.1).

Each specific response developed should include at least some of the following components:

- a designated response coordinator;
- a contact list (e.g. landowner, first responder, other agencies who should be involved);
- the equipment and materials needed for the response, including their location;
- procedures to lessen the impact of the spill;
- procedures to shut down the affected well, or to isolate a section of the distribution system;

- procedures to communicate with other agencies (environmental health officer, R.C.M.P., municipal works, etc.);
- procedures to let water users, in particular high risk individuals, know about the risks;
- sources of emergency water for drinking and other household uses;
- alternative sources of water supply (in case of long-term problems); and
- procedures to decontaminate the well or distribution system.

In developing responses, use the S*M*A*R*T method to identify responses that will work.[2] Appendix 5.1 provides an example of basic standard operating procedures for an emergency response plan.

5.4 Identify Available People and Materials

Who will respond to an emergency? What clean-up materials do you have? Who else can help?

To effectively respond to a spill or to a contamination event, you will need to have properly trained people, a set of response procedures and the proper equipment and materials. Who can provide the technical expertise to assess the seriousness of the threat? If your well does become contaminated, who will treat the water or provide an alternate water supply?[3] These resources may be available within your community or you may need to acquire them from elsewhere.

The contingency plan should include a list of people who can help (see Table 5.1).
This may include people who can:

- Respond to spills (e.g. police, fire-fighters, waterworks company);
- Detect chemical or bacteriological contaminants in the well water (laboratories);
- Provide a temporary supply of potable water (bottled water supplier);
- Repair and restore the water supply (plumbers, water purveyor); and
- Provide information to the public (purveyor, medical health officer).

Identify the "first responder," who has been trained in proper emergency response procedures. This person has the knowledge to identify the relative risks associated with various emergencies, and coordinate and fine-tune the response. First responders are responsible for ensuring that the action items outlined in the emergency response plan are carried out. Often, the first responder will be the local fire or police department. The first responder should be educated about the relative vulnerability of the groundwater resource, the location of the wellhead and other special considerations.

For situations involving potentially hazardous chemicals, work together with local agencies to identify the appropriate first responder. Identify someone who knows how to deal with dangerous goods spills and is available to coordinate the response, and if necessary consider training someone to do these tasks.

In some communities, businesses and industries are responsible for filing a list of hazardous chemicals with the fire department, so that fire-fighters can take the necessary precautions before starting to put out any fire at that location.

A second list should include all the materials and equipment needed to respond to contamination events, such as excavators, trucks, plumbing supplies, and sorbent materials.

5.5 Train Responders

Once a contingency plan has been developed, it is important that everyone who has a role knows about the plan, is clear on his or her roles and is trained. Everyone should know where the emergency equipment, materials, and copies of the plan and maps are located.

Training sessions should be held to ensure that responders are well prepared for their role in case of a spill, detection of contaminated water or other emergency scenarios. Emergency responders should be trained in more than one role so that there are trained back-ups when people are on vacation or cannot be reached. It is also important to have an "Emergency Coordinator" who will be capable of contacting, mobilizing and coordinating the team's work during an emergency.

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[2] See Step Four, section 4.3.

[3] Where a purveyor supplies the water, they will be responsible for ensuring the availability of potable water.

Designate an "Emergency Control Centre." The centre can be as simple as a desk drawer dedicated to emergency response; the idea is to make sure that all of the information needed to implement the contingency plan is organized and accessible, and that all team members are aware of where the contingency plan is located. The centre should be equipped with copies of the team list and the names and phone numbers of other important contacts, and all pertinent information regarding the water supply sources, distribution system, storage system, etc.. A list of contractors capable of repairing the various components of the system and of suppliers who carry power generators and any other equipment that might be necessary for repairs or emergency system operation should also be compiled and kept at the Emergency Control Centre. If available, a cellular phone or radio could be kept at this location to provide a means of communication in case of a phone service outage.

Hold practice emergency drills simulating spills or well contamination from time to time. You will probably identify some shortcomings in your plan and be able to make the necessary changes. Public meetings should also be held to inform the community of the contingency plan and process.

5.6 Develop a Communications Strategy

When water becomes contaminated, you will need to advise water users. Know how to contact those responsible for public water advisories, such as municipal staff, water purveyors and the medical health officer, at any time of the day or night (see Table 5.1). This information should already be part of the emergency response plan of the water purveyors.

The communications section of the contingency plan should state when it is necessary to alert the community, and how this will be done. The area medical health officer or environmental health officer may ask the purveyor to issue a public advisory. Discuss with them how this should be done.

When it is necessary to issue public warnings, do so as soon as possible by radio or television announcements, signs at public locations or even by distributing notices door-to-door in high risk areas such as seniors complexes, day-care centres and hospitals. Smaller communities may be able to use a telephone tree approach.[4] In the event of on-going water contamination, use radio, television and newspaper reports to inform customers about the situation and steps that are being taken to solve the problem, and to advise on ways to minimize the risk to consumers.

Prepare draft press releases and mail-outs in advance. Then when public warnings are required it is only necessary to fill in details and produce enough copies for mailing to affected areas, or provide local media with the prepared statement. Examples are included in Appendix 5.2. A list of media contacts should be prepared – the media can assist in broadcasting the information.

5.7 Update Existing Maps

The contingency plan should include maps and plans with information that will be useful in case of a contamination event, such as:

- the shut-off for the well pumps;
- the water and sewer distribution system, including valves and other control points;
- potential contaminant sources in the well protection area;
- locations of emergency equipment and clean-up materials which can be used to respond to spills or other emergencies; and
- diagrams of electrical systems in pump houses.

You may be able to add to the maps developed in Steps One and Three, and/or to develop new overlays.

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[4] In a telephone tree, one person notifies everyone on their contact list (five - ten people), who in turn each contact everyone on their list, and so on.

It is useful to have maps at different scales, reflecting the level of detail that will be needed to aid in responding to different contamination events. For example, the overview map of potential contaminant sites in the well protection area may be mapped at a 1:20,000 scale. Another map showing the details within the one-year time of travel zone may be mapped at a 1:1,000 scale.

The plan of the distribution system should identify the type of construction material used. This is important because certain contaminants can affect parts of a distribution system. For example, acidic contaminants can increase corrosion of concrete pipes or reservoirs. Some organic compounds can adsorb onto the surface of plastic pipes and continue to contaminate water long after the source of contamination has been cleaned up.

5.8 Secure Alternative Water Supplies

Alternative water supplies may be required if your well becomes contaminated. Although access to an alternative water supply is part of the emergency response plan, making the necessary arrangements and ensuring any written agreements with alternate water suppliers are in place before any contamination event occurs is really contingency planning.

Outbreaks of waterborne disease, or contamination with bacteria, viruses or parasites can generally be dealt with through public advisories to boil water. However, alternate supplies may be required for institutions such as care facilities, schools and public buildings where some water users are susceptible to illness.

You will also need to identify emergency supplies that can be made available on very short notice. For example, bottled water suppliers and bulk water haulers could provide water to institutions such as schools and care facilities during boil advisories and possibly to private homes in the event of chemical contamination.

The planning team or purveyor should also have plans to secure an alternate source of water that can be connected to the distribution system to replace a contaminated well. If it is too expensive or impossible to clean-up the original well, you may want to identify an alternate well field site for drilling a back-up well, and/or secure the right to use an available surface water source.

If possible, set aside some land where a new well could be drilled. This may require purchasing property. As a precaution, this alternate well site should be outside of the one-year time of travel area for the existing well. At the same time, it needs to be close enough to allow it to be easily connected to the existing water system. This site may also be needed to meet future water needs as your community grows, and therefore, costs associated with obtaining and protecting it may eventually be recovered from homeowners in the new developments. The assistance of a professional hydrogeologist to locate and supervise drilling and testing is recommended.

Many water systems have more than one well. If any one well is contaminated, delivery of the supply can still be maintained at a minimum level by altering the pumping schedule of the remaining wells in the well field. The planning team should develop a contingency strategy to continue the operation of the well field in case of contamination to any one well.

5.9 Identify Funding to Implement the Contingency Plan

Think about how you will pay for an emergency clean-up or the provision of alternative water supplies. Consider establishing a reserve fund for emergency responses. Your local government or the Provincial Emergency Program may be able to help. The Ministry of Municipal Affairs may provide funding for upgrades in infrastructure, or planning grants.

CHECKLIST FOR STEP FIVE

The following is a basic checklist for action items to be completed during Step Five of the well protection planning process:

ACTION ITEM	COMMENTS	COMPLETED
Decide who is responsible for this action	Enlist technical and volunteer assistance if required.	☐
Identify possible contamination events	Identify possible events for each of the potential contaminant sources.	☐
Develop responses	Use S*M*A*R*T method to identify appropriate responses.	☐
Identify people and materials	Know who to contact for each type of event, and how to reach them.	☐
Develop a communications plan	Be ready to issue a public water advisory at short notice.	☐
Be prepared	Train people if necessary. Carry out simulations to ensure the plans work well.	☐
Update maps	Ensure all relevant information is included on maps.	☐
Secure alternative water supplies	Be prepared for short- and long-term loss of water supply.	☐
Secure funding	Look at how you will pay for emergency responses.	☐

Appendix 5.1 Emergency Response Plan - Standard Operating Procedure Examples

These responses may be adequate for very small waterworks or where resources are limited.

EXAMPLE: TANKER TRUCK CHEMICAL SPILL WITHIN ONE YEAR TIME OF TRAVEL ZONE

Actions:

- Contact first responder John Doe – 555-4567 (work); 555-8901 (home);
- Determine what chemical has been spilled – check the placards on vehicle, contact truck owners for verification and information on how dangerous the chemical is, and find out what precautionary measures are recommended (such as evacuation of the area and protective clothing);
- Refer to 1996 *North American Emergency Response Guidebook* for details;[5]
- Contact Ministry of Environment, Lands and Parks – 555-5678;
- Contact Medical Health Officer – 555-2345;
- Contact Fire Department – 555-6789;
- Contact R.C.M.P. for crowd control and accident investigation – 555-0123;
- Contact Provincial Emergency Program (250) 387-5956;
- Evacuate immediate vicinity of crash site.

First Responder must verify appropriateness of the following steps:

- If truck contents are explosive, or produce toxic fumes, expand evacuation area (Refer to 1996 *North American Emergency Response Guidebook*);
- Contain spill if necessary (block drainage ditches or dig interceptor trench to minimize extent of area which will need to be cleaned up);
- Recover spilled chemical, pump to containers, and ensure pump and container are appropriate for the chemical (e.g. corrosive chemicals may dissolve regular drums).

---

[5] U.S. Department of Transporation and Transport Canada, 1996. *North American Emergency Response Guidebook* U.S. Department of Transportation, Research & Special Programs Administration; Transport Canada, Safety & Security, Dangerous Goods; Secreteriat of Transport and Communications.

Appendix 5.2 Sample Press Releases and Mail-Outs

Boil Advisory for Bacterial Contamination:

The __________ (water utility, etc. name) has been advised by Dr. _______ (name), Medical Health Officer, ________ (Community Health Services Society or Regional Health Board) that unacceptable levels of coliform bacteria have been detected in the drinking water system of the ________area (entire waterworks or a specific area). Residents are advised to boil their drinking water for two minutes prior to consumption or prior to washing vegetables, brushing their teeth or using it in the preparation of foods that won't be cooked such as salad dressings, ice cubes or juices. Bottled water may also be used as an alternative to tap water.

Tap water is still acceptable for other household uses such as laundry or showering, but care should be taken not to swallow water when showering or bathing.

For further information contact ___________ (name, phone number)

Chemical Contamination Advisory:

The __________ (water utility, etc. name) has been advised by Dr. _______ (name), Medical Health Officer for the ________ (Community Health Services Society or Regional Health Board) that unacceptable levels of ________________ (chemical name) have been detected in the drinking water system of the ________area (entire waterworks or a specific area). Residents are advised that __________ ____ (chemical name) can result in ______ (information about possible health effects from MHO). Tap water should not be used for consumption or washing vegetables, brushing teeth or using in the preparation of foods, ice cubes or juices. Bottled water should be used as an alternative to tap water.

Tap water is still acceptable for other household uses such as laundry or showering (this must be verified by the Medical Health Officer - some chemicals may pose a risk if you breathe them in the shower stall), but care should be taken not to swallow water when showering or bathing.

For further information contact ___________ (name, phone number)

STEP FIVE: Contingency Planning

Develop Scenarios

At this step, the Pumphandle team reviewed all the potential sources of contamination in the well protection area. The water purveyors – Andrew Aiken, Jenny Lowden and Eric Kowski – provided copies of their emergency response plans to the team. Jenny Lowden offered to lead the development of a set of standard operating procedures (SOPs) that could be used to respond to each type of emergency situation. The SOPs would be the basis of the responder training.

The existing emergency response plans already contained details on how to deal with such issues as the contamination of the distribution system through water main breaks or back flow of contaminated water, and the loss of supply either from pump breakdown or power failure.

After some discussions, Jenny's group decided that the overall contingency plan for the well protection area would include the separate emergency response plans from each water system. Jenny's group would develop a common set of training scenarios. This would ensure that the response to an emergency at Blackwater Well would be the same at the other two community wells.

Andrew, Jenny and Eric would continue to be responsible for updating and implementing their emergency response plan as required by the Safe Drinking Water Regulation. They would pass on any revisions to the Pumphandle team so the contingency plan could be kept up to date.

Before Jenny and her group could start developing the SOPs they needed to identify the types of events that would trigger a response (Table CS 5.1). They listed the following two events:

1. Routine monitoring detected contaminants in the groundwater; or
2. The planning team received reports of chemical spills, discharge or bad practices within the well protection area or directly into a well.

Inventory Resources

Jenny's neighbour, Dhrubo Osis, was a five-year veteran of the Pumphandle Volunteer Fire Department. When Jenny told him about her current project with the Pumphandle community planning team, Dhrubo offered to help her with the contingency plan. Through his work with the fire department, Dhrubo knew that Pumphandle Valley had several first responders within the community who were trained in handling chemical spills: the local R.C.M.P. detachment, the Ministry of Environment, Lands and Parks and, of course, the Pumphandle Volunteer Fire Department and the local health authority.

Dhrubo also suggested that they sign a rental agreement with AAA Excavation Services for the supply of equipment for excavation work. He included a clause that said the community planning team had priority over other customers during an emergency situation. The need to access heavy equipment on short notice could happen in an emergency. Planning ahead would help with a quick response to an emergency.

At the same time, Jenny and the other water purveyors put together a list of pumps, sump-pumps, piping and other waterworks supplies that essential in an emergency situation. Although each purveyor had some supplies on hand, they decided to combine their money to purchase more water system construction supplies in case of an emergency. Jenny offered to store the supplies at Blackwater Waterworks.

High on the list of priorities for the contingency plan is an alternate supply of water. Barney Buhler of Barney's Bulk Water Service in Valleyview was given a contract to supply bulk water to Pumphandle and its residents in case of an emergency. This contract also included a "priority" clause, where Barney would give first priority to Pumphandle. The volunteer fire department would help Barney to distribute the water to the residents. Barney also

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TABLE CS 5.1 CONTINGENCY RESPONSES TO POTENTIAL CONTAMINANTS

Most Likely Event	Trigger	Contaminant Source/ Activity	Contingency Activity	Contact
Nitrate contamination of Allan's, Blackwater or Charlie's Wells	Water quality monitoring Report of bad practices	Hay fields (A-1, 2, & 3) Corn fields (A-5 & 6) Golf course (C-3) Subdivision (R-1), subdivision and campground (R-2)	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source	Environmental Health Officer (EHO) Water purveyor of affected well
Pesticide contamination	Water quality monitoring Report of bad practices	Golf course (C-3)	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source	EHO Water purveyor of affected well Ministry of Environment, Lands and Parks (MELP)
Gasoline contamination	Complaint of odour in the water Water quality monitoring Spill reported	Gas station	Contact MELP Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source Contain spill	EHO Water purveyor of affected well MELP
Dry cleaning liquid contamination	Water quality monitoring Spill reported	Dry cleaner	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source Contain spill	EHO Water purveyor of affected well MELP
Chemical spill or road salt contamination	Water quality monitoring Spill reported	Main road	Clean up spill Issue public advisory Provide alternate drinking water Expand monitoring to determine source Contain spill	MELP Fire department EHO Water purveyor of affected well
Contamination by household wastes	Water quality monitoring	Subdivision (R-1 and/or R-3) Subdivision and campground (R-2)	Issue public advisory Chlorinate affected well if bacteria present Provide alternate drinking water Expand monitoring	EHO Water purveyor of affected well

offered to coordinate and supply bottled water from his brother's bottling plant in Valleyview.

Fortunately, each of the water purveyors had on-site generators capable of powering their pumps in case of an electrical service failure.

Modify Maps

Jenny, Andrew and Eric have large-scale maps (1:500) showing the entire distribution system as well as detailed plans of each valve and wellhead for each of their water systems. A new map overlay was developed for the TRIM map to show the distribution system mains (Figure CS 5.1).

Develop Specific Responses to Each Event

With help from Dhrubo, Jenny's group listed the following for each emergency situation:

- Contingency responses to each potential contaminant source;
- The specific contaminants expected;
- The trigger that would initiate a contingency response;
- The most likely and most probable events resulting from the contaminant sources; and
- Contingency activities for each contaminant source.

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Chemical spill or road salt contamination	Water quality monitoring Spill reported	**Main road**	Clean up spill Issue public advisory Provide alternate drinking water Expand monitoring to determine source Contain spill	**MELP Fire department EHO Water purveyor of affected well**
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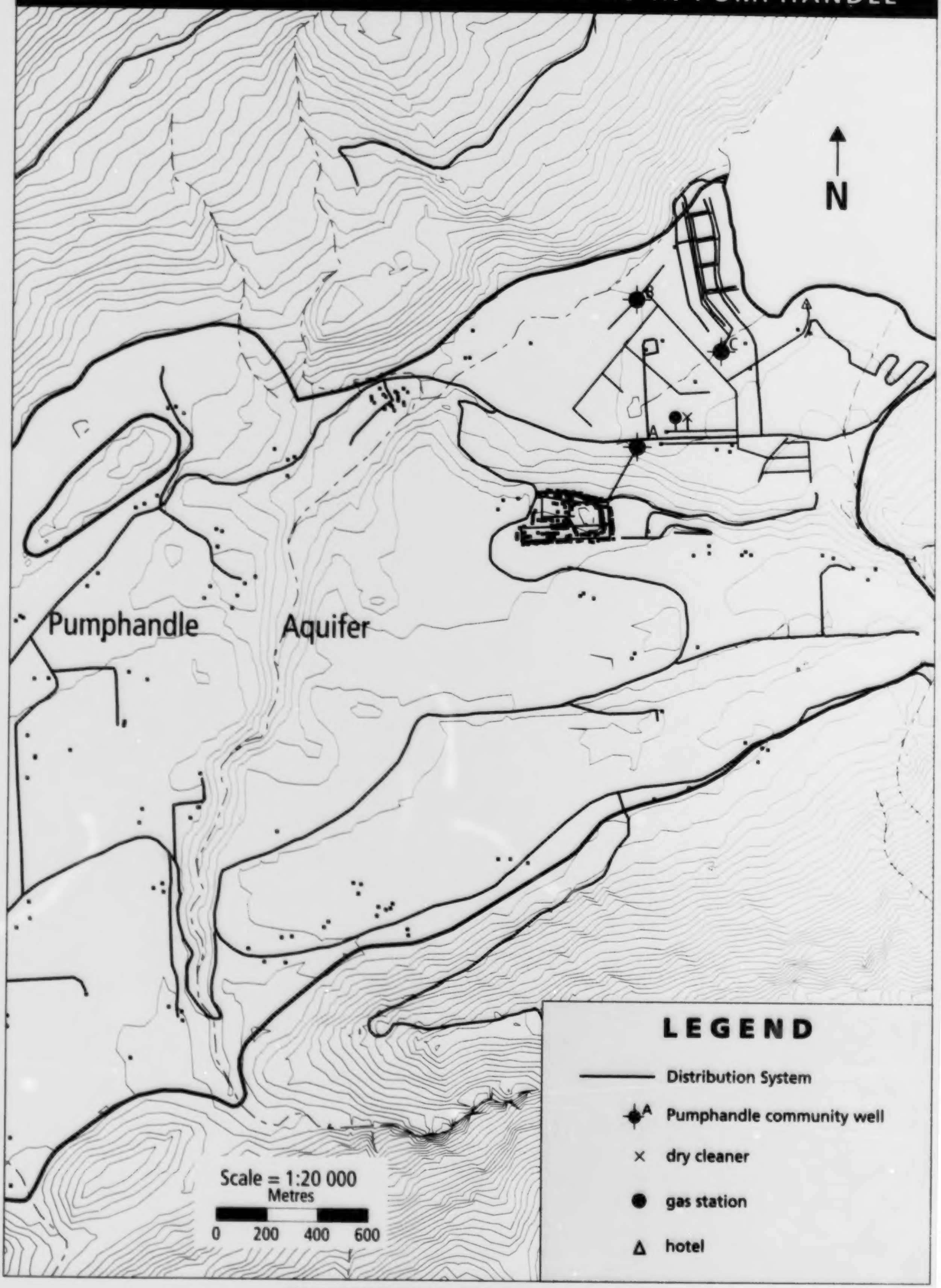
- The most likely and most probable events resulting from the contaminant sources; and
- Contingency activities for each contaminant source.

FIGURE CS 5.1 DISTRIBUTION SYSTEMS IN PUMPHANDLE


N
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A
B
C
LEGEND
Distribution System
A Pumphandle community well
× dry cleaner
● gas station
Δ hotel
Scale = 1:20 000
Metres
0 200 400 600

Table CS 5.1 summarizes the list the group developed.

They concluded that none of the sources was likely to result in significant levels of contamination. However, some of the potential contaminants could still pose a serious problem, either as a health threat (e.g. perchloroethylene or nitrates) or other problems that could render the water unfit for use (such as gasoline, which is unpalatable even at levels too low to pose a health threat).

The group identified six short-term contingency activities:

- Contain and/or clean spill and contaminated soil;
- Determine public health significance of contaminant;
- Issue public advisories;
- Provide alternative water supply;
- Expand monitoring program to determine if other contaminants are present and to identify the source and extent of contamination; and
- Chlorinate water supply.

For each contingency activity the group applied the S*M*A*R*T test. At this point, Jenny called a meeting of the full planning team to go over the progress her group had made towards developing a contingency plan. She wanted to make sure that she and her group had not overlooked anything obvious.

Routine monitoring for bacteria might not detect contamination with bacteria or viruses soon enough to protect consumers from a waterborne disease outbreak. The planning team asked local physicians and pharmacies to let them know if there was an increase in physician visits for diarrhoea, or in sales of anti-diarrhoea medicine.

Longer-term contingency activities include installing treatment facilities, linking the three waterworks and drilling a new back-up well.

The planning team concluded that the contaminant most likely to affect any of the community wells was nitrates from either fertilizer or septic wastes. All of the wells have potential contaminant sources within their capture zones, but Blackwater Well is slightly less vulnerable as it is located farther from most potential contaminant sources than Aiken's and Charlie's Wells. Since Blackwater Well is at least risk, and produces the greatest amount of water, one option suggested was to connect all three community water supplies so that Blackwater Well could supply water to all residents. This would be especially beneficial since the peak use demands on Aiken's Well already exceed supply. Some of the costs of connecting the three distribution systems could be offset by the cost saving of not drilling a new well to replace Aiken's. Finding the funds to connect the systems was identified as a priority.

Develop a Communication Plan

The communication plan developed by the planning team included two main elements:

- Communication with people and agencies necessary to respond to a specific event; and,
- Communication with water users who may be affected by a contamination event or interruption in water supply.

The team developed a master list of phone numbers of agencies and individuals who would respond to the various scenarios, including emergency situations. These were listed in order of priority. The list included the name of the agency, the contact and phone numbers both at work and at home for those people.

Draft public advisories were developed. In the event that a public advisory is needed, a specific concern such as unsatisfactory bacteria tests or chemical contamination can be inserted into the draft. When a public advisory is needed, press releases will be sent to the Pumphandle community newspaper and the Valley radio station, and notices delivered directly to individual homes.

Secure Additional Materials and Resources

Applying the S*M*A*R*T test to the contingency activities identified several resources which were not currently available in Pumphandle. The planning team made a list of materials and resources to acquire:

- Sorbent materials for dealing with spills;
- Alternate water supplies (short term supply);
- Emergency chlorinator and attachment sites;
- Protocols for fire fighting at the dry cleaners and gas station which would minimize spread of contaminants to the aquifer; and
- Access to monitoring wells (existing private wells located between community supplies and potential contaminant sites).

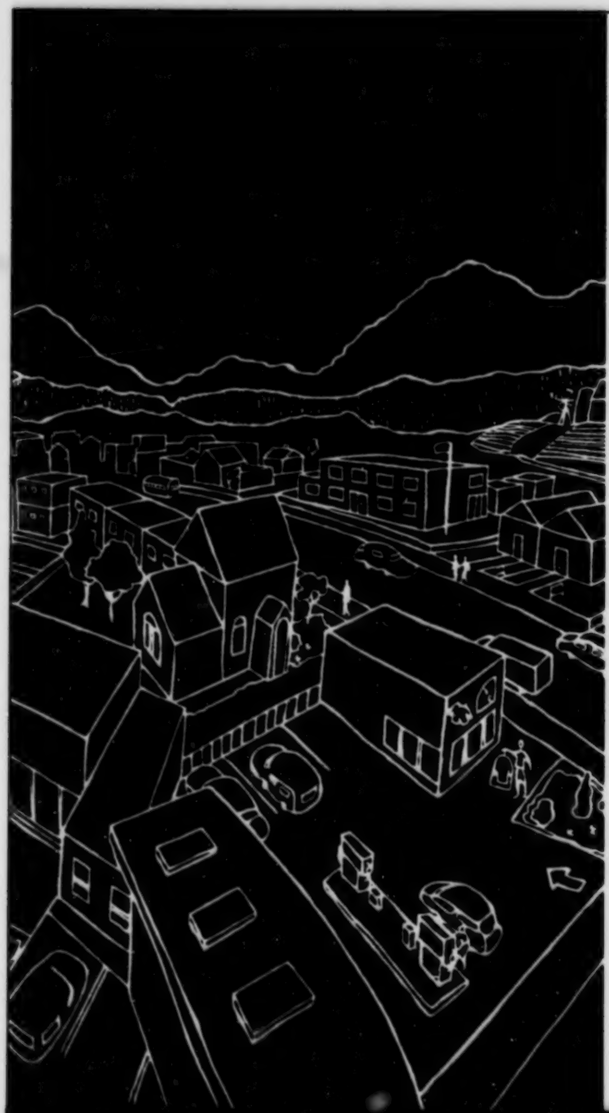
Discussions were held with private well owners, sorbent materials were purchased, arrangements were made for short-term alternate water supplies, and fire-fighting protocols were developed. The three water purveyors agreed to purchase a chlorinator and to install fittings at their well heads, which would allow the chlorinator to be attached in the event that their wells become contaminated with pathogens.

Other needs identified during contingency planning included a long-term alternate water supply (new well), and additional funding to purchase equipment and supplies for the contingency plan. These needs were beyond the ability of the planning team to arrange on a short-term basis, and the planning team decided to ask the local government for assistance.

Implement the Plan and Acquire Additional Resources

The planning team developed an Implementation Plan, which involved preliminary training of those people with a responder role identified in specific responses. This included providing people with short lecture sessions to look over the plan, workshops to provide different "what if..." scenarios and running mock spill exercises for hands-on training.

The planning team discussed long-term needs with the Regional District. In particular assistance was needed to secure an alternate well site, and to connect the three existing waterworks systems. The long-term vision was to develop a single waterworks system with a series of back-up wells.



Step Six

MONITOR RESULTS AND EVALUATE THE PLAN

Summary 2

STEP SIX – Monitor Results and Evaluate the Plan

- 6.1 Monitor Water Quality and Quantity 3
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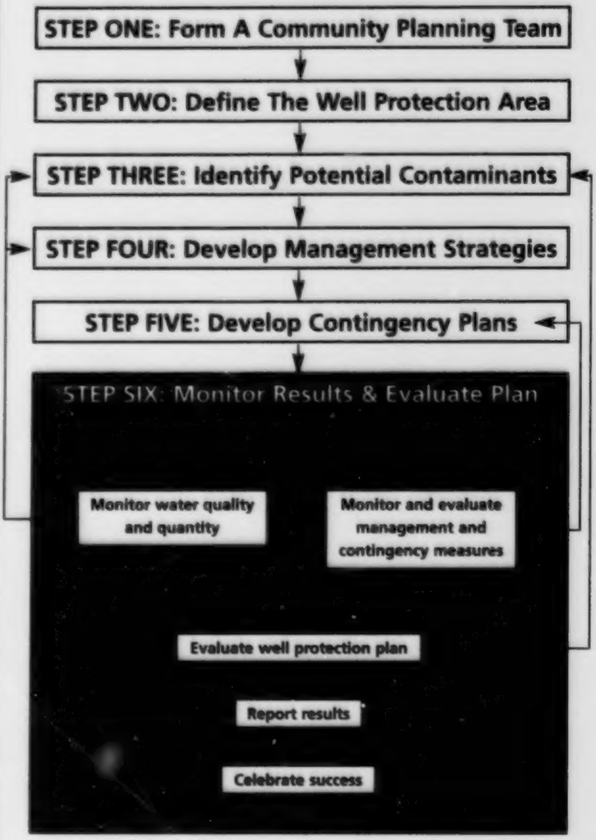
Figure 6.1


STEP ONE: Form A Community Planning Team
STEP TWO: Define The Well Protection Area
STEP THREE: Identify Potential Contaminants
STEP FOUR: Develop Management Strategies
STEP FIVE: Develop Contingency Plans
STEP SIX: Monitor Results & Evaluate Plan
Monitor water quality and quantity
Monitor and evaluate management and contingency measures
Evaluate well protection plan
Report results
Celebrate success

More than 750,000 British Columbians rely on groundwater as their source of drinking water, and there are thousands of community well systems in British Columbia. A well protection plan allows communities to identify land use activities that may threaten the quality of their well water, and to develop a strategy to avoid or minimize these threats.

There are six steps to follow in developing a well protection plan:

1. Form a community planning team
2. Define the well protection area
3. Identify potential contaminants
4. Develop and implement management strategies
5. Develop contingency plans
6. Monitor results and evaluate the plan

These steps are described in the six booklets that make up the *Well Protection Toolkit*. Each booklet describes activities that lead to the development and implementation of a well protection plan. In each step, a fictional case study of the town of Pumphandle shows how one community took on this challenge.

Step Six: Monitor Results and Evaluate the Plan

The sixth step is to make sure that the well protection plan is working. By setting up a system to monitor water quality, the team will be alerted if there are contaminants in the groundwater supply, and will know if the groundwater quality is improving. It is also important to evaluate the well protection plan itself. Are you meeting your goals and objectives? Have all the proposed action items been completed? If there was a contamination event, did your contingency plan work? It may be necessary to adjust the plan to cope with new land-use activities.

The results of the monitoring and evaluation should be made available to members of the community so that they can see the plan is working, and can make comments on its progress.

Figure 6.1 shows the stages of Step Six.

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Monitor Results and Evaluate the Plan

OBJECTIVES

- To monitor and evaluate water quality and quantity
- To evaluate the protection and contingency activities
- To report the results of the monitoring and evaluation
- To evaluate and update the well protection plan

It is important to monitor the various protection activities, compare the results with the goals set out in the plan, and to evaluate how well the goals were met, so that the planning team can assess the success or failure of these efforts.

6.1 Monitor Water Quality and Quantity

You will need a system for monitoring water quality in the well protection area and in the community. The results will tell you whether you are meeting your main objective of safeguarding the community water supply, and will help you to detect any contamination. However, if water quality is monitored only at the well(s) or in the distribution system, there is no time to detect contamination before it reaches the well.

Water purveyors are responsible for collecting data and monitoring water quality in their water system and this data can be useful to the planning team. Water quality monitoring should therefore include the surrounding capture zone. Monitoring wells placed at strategic locations in the well protection area (for example between known or suspected sources of contamination and the community well) will provide advance warning of problems.

The planning team can arrange to have monitoring wells installed,[1] or may be able to use domestic wells that are suitably located, including the right depth, provided the well owners' permission has been obtained.[2] The frequency and intensity of monitoring within the well protection area will be based on factors such as distance to the community well, vulnerability of the aquifer, degree of pollution threat, and expected consequences. You should also have a Quality Assurance/Quality Control (QA/QC) procedure for sampling.

Design of the monitoring well network is complex and requires the help of a professional hydrogeologist.[3] A hydrogeologist can develop, implement and assess the results of the groundwater monitoring program. Draft terms of reference for hiring a hydrogeologist to do this work are included in Appendix 6.1.

Information on the quantity of the water supply is equally important. Data on the well water level (pumping and non-pumping), the volume pumped, as well as water levels in the aquifer[4] are critical for on-going operation of the well supply. This information is also valuable for planning the development of additional groundwater supplies for the community.

Interpreting the water quality monitoring data will require some effort. Keep the data up-to-date and review it on a regular basis, so that you can detect any contamination events quickly and respond appropriately to emergencies.

6.2 Evaluate Management Activities

Have the management activities (Step Four) been implemented properly? Are they helping to reduce the risk of contamination? Community groups and professional associations can help in evaluating these activities. For example, agricultural producer groups or other farmers could evaluate whether farmers in the protection area are adopting Best Management Practices for the handling and storage of manure. Appendix 6.2 provides a list of common activities and suggests who should monitor them and how.

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[1] Monitoring wells are typically 5 cm to 15 cm (2-inch to 6-inch) in diameter.

[2] Location and information on domestic wells can be obtained through a field survey and/or the Ministry of Environment, Lands and Parks' water well database (http://www.elp.gov.bc.ca/wat/gws/)

[3] A list of groundwater consultants in B.C. can be found in the Ministry of Environment, Lands and Parks' groundwater home page (http://www.elp.gov.bc.ca/wat/gws/)

[4] Measured from the water levels in monitoring wells.

Monitor Results and Evaluate the Plan

OBJECTIVES

- **To monitor and evaluate water quality and quantity**
- **To evaluate the protection and contingency activities**
- **To report the results of the monitoring and evaluation**
- **To evaluate and update on the well protection plan**

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Interpreting the water quality monitoring data will require some effort. Keep the data up-to-date and review it on a regular basis, so that you can detect any contamination events quickly and respond appropriately to emergencies.

6.2 Evaluate Management Activities

Have the management activities (Step Four) been implemented properly? Are they helping to reduce the risk of contamination? Community groups and professional associations can help in evaluating these activities. For example, agricultural producer groups or other farmers could evaluate whether farmers in the protection area are adopting Best Management Practices for the handling and storage of manure. Appendix 6.2 provides a list of common activities and suggests who should monitor them and how.

---

[1] Monitoring wells are typically 5 cm to 15 cm (2-inch to 6-inch) in diameter

[2] Location and information on domestic wells can be obtained through a field survey and/or the Ministry of Environment, Lands and Parks' water well database (http://www.elp.gov.bc.ca/wat/gws/)

[3] A list of groundwater consultants in B.C. can be found in the Ministry of Environment, Lands and Parks' groundwater home page (http://www.elp.gov.bc.ca/wat/gws/)

[4] Measured from the water levels in monitoring wells.

The results of the evaluation surveys and other monitoring tools provide the planning team with information as to whether individual protection efforts are working. This is an opportunity to re-visit some of the management options outlined in Step Four. Should some other options be implemented? Should current measures be stopped or changed? Some of the management activities may have had a phased approach – are these still on time and on-track? Use this information to update your well protection plan.

6.3 Evaluate the Well Protection Plan

In addition to evaluating the individual actions, you should also look at the well protection plan itself. Ask yourself:

- Is it achieving its objectives? (If not, why?)
- Is there more or new information that can be added to the plan?
- Do contact lists need to be updated?
- What worked? What didn't? How can improvements be made?
- What were the costs of implementing the plan?

Much of this information will come from the results of sections 6.1 and 6.2. The review should focus on the plan's overall effectiveness as well as the merits of the individual components of the plan.

The well protection plan should be reviewed every year. Review of the plan will lead to decisions regarding any plan revisions and the development of next year's action plan.

6.4 Report the Results

Keep the public informed of the progress of the well protection activities. Publish an annual report on the plan and its activities. An example outline for an annual report on the well protection plan is shown in Appendix 6.3. This should include report on the water quality results and a summary of the protection activities underway. This will help build support for the protection efforts, and provides an opportunity for public input.

Results can be reported to the public in a variety of ways. For example:

- Prepare written reports and have them available on request;
- Include fact sheets and information bulletins with the water bill. To allow feedback, comment forms and/or a contact phone number should be included;
- Set up information display booths at trade fairs and shopping centres;
- Prepare press releases for the local media, and suggest they interview members of the planning team;
- Hold public meetings at which the planning team reports on results, and use this opportunity to seek public input into changes required to the well protection plan.

Prepare reports and information in a form that can be easily understood by the intended audience.

A written report is appropriate to formally communicate successes/failures of the plan at year-end, while fact sheets and press releases may be suitable as interim reports. Make a list of all of the key individuals who should receive this information, such as the Medical Health Officer; the Board of Directors of the community waterworks system, the municipality and regional district, and local conservation groups.

6.5 Celebrate Success

Don't forget to celebrate your successes! The planning team should take the time to reflect on what it has achieved.

Developing a well protection plan is a dynamic and exciting process. You will certainly learn a great deal about your community water supply – and the community itself. There will be frustrations – when you can't get information you need, or the planning team cannot agree on priorities. But there will also be a great sense of achievement. You have contributed to the protection of one of the community's greatest assets (and vital requirements) – your drinking water.

CHECKLIST FOR STEP SIX

The following is a basic checklist for action items to be completed during Step Six of the well protection planning process:

ACTION ITEM	COMMENTS	COMPLETED
Decide who is responsible for this action	Enlist technical and volunteer assistance if required.	☐
Monitor water quality and quantity	Set up a system of monitoring wells.	☐
Evaluate individual management and contingency measures	Design a system for evaluation when implementing the measures.	☐
Evaluate the well protection plan	Evaluate annually Make adjustments to the plan as necessary.	☐
Report results	Seek public input.	☐
Celebrate success	Take the time to reflect on what the planning team has achieved.	☐

Appendix 6.1 Terms of Reference for Developing and Implementing a Groundwater Monitoring Program

Only general terms of reference are provided here. Specific terms of reference depend on site-specific conditions and factors and can only be developed after these are adequately known. It may be useful to contact the Groundwater Section of the Ministry of Environment, Lands and Parks for advice in drafting specific terms of reference.

- Review available information to identify critical areas to achieve the following objectives: 1) monitoring water quality to protect the quality of the community well supply and 2) detecting contamination in the aquifer before it reaches the community well.
- Outline locations of monitoring sites, monitoring depths, sampling procedures, parameters to monitor, frequency and schedule of monitoring, and a QA/QC program for collection of monitoring data. Include costs for establishment of monitoring sites, data collection, and QA/QC of monitoring data.
- Provide training to sampling staff: including sample collection and preservation protocols; QA/QC procedures; documentation; sample handling and shipping procedures; analyzing water quality results. Include a training manual.
- Sample monitoring sites, track sample collection, and QA/QC samples.
- Store monitoring data in the data management system that allows data to be readily manipulated, retrieved, displayed, and plotted.
- Conduct brief analysis of monitoring data after every sampling round to check for trends, substances that exceed drinking water guidelines, make recommendations, and write a brief progress report.
- Write annual report on results of water quality monitoring, including discussion on results, causes of observed trend, whether monitoring objectives are being achieved, and recommendations.

M121

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Appendix 6.2 Summary of Typical Well Protection Monitoring Activities

APPENDIX 6.2 SUMMARY OF TYPICAL WELL PROTECTION MONITORING ACTIVITIES

[illegible]	Purpose of monitoring	[illegible]	Responsibility	[illegible]
[illegible]	Detect any changes in quality Assess the effectiveness of land use and protection strategies on water quality	[illegible]	Water purveyor MOH[5] MELP[6] Industry	[illegible]
[illegible]	Detect any changes in water levels from water/land use which may adversely affect supply	[illegible]	Water purveyor MELP	[illegible]
[illegible]	Ensure that unused wells are properly abandoned and wastes are not dumped down the well Ensure community well is being properly maintained and operating properly Update knowledge of water use in the area which may affect water quality or capture zone boundary	[illegible]	Water purveyor Well owners Local government Drillers (BCGWA)[7] MELP	[illegible]
[illegible]	Ensure that proper practices are being implemented	[illegible]	Farmers, ranchers, and local residents Producer groups MAF[8] MELP	[illegible]
[illegible]	Ensure that proper practices are being implemented Ensure pollution sources are being removed Assess water quality impact and compliance monitoring at regulated waste disposal activities	[illegible]	Local government MEM[9] MELP	[illegible]
[illegible]	Ensure that proper practices are being implemented	[illegible]	Local government Local residents	[illegible]
[illegible]	Assess impact of activities on raising public awareness and stewardship	[illegible]	Water purveyor Local and provincial governments Local residents	[illegible]

[5] MOH: Ministry of Health, [6] MELP: Ministry of Environment, Lands and Parks, [7] BCGWA: B.C. Ground Water Association
[8] MAF: Ministry of Agriculture and Food, [9] MEM: Ministry of Energy and Mines

Appendix 6.2 Summary of Typical Well Protection Monitoring Activities

APPENDIX 6.2 SUMMARY OF TYPICAL WELL PROTECTION MONITORING ACTIVITIES

General Categories	Purpose of monitoring	Some typical examples	Responsibility	How to evaluate
Water quality	Detect any changes in quality Assess the effectiveness of land use and protection strategies on water quality	**Quality of the well water** **Ambient water quality in the aquifer**	Water purveyor MOH[5] MELP[6] Industry	**Compare water quality to drinking water and other guidelines** **Assess water quality trend over time**
Water level	Detect any changes in water levels from water/land use which may adversely affect supply	**Water levels in the community well** **Water levels in observation wells in the aquifer**	Water purveyor MELP	**Assess water level trend over time** **Determine/interpret causes of water level fluctuation from the hydrograph**
Well use and abandonment practices	Ensure that unused wells are properly abandoned and wastes are not dumped down the well Ensure community well is being properly maintained and operating properly Update knowledge of water use in the area which may affect water quality or capture zone boundary	**Quantities pumped from the community and other major wells** **The type of water use** **The number of new wells and construction practices** **The number of wells abandoned and abandonment practices**	Water purveyor Well owners Local government Drillers (BCGWA)[7] MELP	**Compare actual practice against recommended practices and provincial guidelines** **Compare the specific capacity of the well over time to check if efficiency is maintained**
Agricultural land use practices	Ensure that proper practices are being implemented	**Agricultural manure storage and handling practices** **Fertilizer and pesticide use practices** **Irrigation practices** **Enforcement of Code of Agricultural Practice for Waste Management** **Implementation of Integrated Pest Management Plans (IPMs) and Nutrient Management Plans (NMPs)**	Farmers, ranchers, and local residents Producer groups MAF[8] MELP	**Compare actual practices against recommended practices and requirements specified in the operating permits**
Industrial and commercial land use practices	Ensure that proper practices are being implemented Ensure pollution sources are being removed Assess water quality impact and compliance monitoring at regulated waste disposal activities	**The number of leaky underground storage tanks removed** **Compliance monitoring around permitted waste disposal sites and contaminated sites** **Illegal dumping in gravel pits and gravel extraction practices**	Local government MEM[9] MELP	**Compare actual practices against recommended practices and monitoring requirements specified in the operating/discharge permits**
Residential land use practices	Ensure that proper practices are being implemented	**Septic system maintenance** **Fertilizer and pesticide use** **Disposal of household toxic wastes**	Local government Local residents	**Compare actual practices against recommended practices, requirements specified in by-laws and covenants**
Public educational activities	Assess impact of activities on raising public awareness and stewardship	**Questionnaires, surveys, and opinion polls**	Water purveyor Local and provincial governments Local residents	**Compare against baseline and/or previous data**

[5] MOH: Ministry of Health, [6] MELP: Ministry of Environment, Lands and Parks, [7] BCGWA: B.C. Ground Water Association

[8] MAF: Ministry of Agriculture and Food, [9] MEM: Ministry of Energy and Mines

Appendix 6.3 Outline for an Annual Report on the Well Protection Plan

Executive Summary

- Usually one page or less describing concisely what was done, the results, and any major recommendations.

Introduction

- Background on the well protection plan (e.g. history, objectives, justification, etc.);
- Terms of reference for the plan;
- Outline what the report will address.

Well Protection Plan

- Outline of annual plan (i.e. what was planned for the year).

Plan Activities

- Report on plan activities (i.e. what was done for the year);
- Report results of monitoring;
- Include costs of the various activities.

Discussion

- Discuss results, including what worked and what didn't work for the activities and for the plan on the whole;
- Discuss implementation for continued work.

Conclusions and Recommendations

- Summarize plan activities and discussion;
- List recommendations for next year's operating plan.

Appendices

- Include more detailed and technical information which may not be included in the main body of the report;
- Include statement of financial accounts for the various well protection plan activities.

STEP SIX:
Monitor Results and Evaluate the Plan

The Pumphandle Well Protection Plan spans a two-year period from spring 1999 to spring 2001. Monitoring and evaluation activities apply to the first year only – these too will be re-evaluated at the end of year one.

Monitor Protection Activities

At the end of the first year, the planning team conducted a questionnaire survey in the community and held interviews with selected landowners and residents. The evaluation looked at the Best Management Practices (BMPs) and Integrated Pest Management (IPM) approaches, using information gathered by team members.

Farmers

The results indicted that all farmers except one (the owner of the cornfield at A-6) had begun to adopt BMPs and IPM. The farmers started by properly storing their fertilizers, pesticides and fuels in covered areas away from watercourses and wells. They had consulted *Watershed Stewardship: A Guide for Agriculture*,[10] and jointly hired a consultant to advise them on developing IPM and water-wise irrigation methods to minimize leaching of agricultural chemicals into the aquifer.

Golf Course Owner

The golf course owner had also initiated BMPs/IPM by properly storing fertilizers, pesticides and fuels in their maintenance area. He also began consulting experts on better ways to irrigate and manage the golf course according to the guidelines in *Greening Your Golf Course: A Guide to Environmental Management*.[11] The administrative staff had posted information about their protection efforts on the club bulletin board.

Gas Station Owner

The gas station owner had tested the tanks and did not find any leaks. He therefore decided not to install new tanks at this time.

Owner of Abandoned Well

The owner of the abandoned well did not grout off the well due to a lack of funds.

Dry Cleaner Operator

The dry cleaner operator did not attend a spill response course due to a lack of funds.

The survey indicated that the two-page newsletter sent out by the Regional District did a good job of communicating the well protection initiative but the details of each protection measure were not as clear. The survey also found that where a protection measure would involve costs of more than $300 (e.g. grouting off abandoned well or taking the spill response course), landowners were not prepared to bear this cost alone.

Two signs were erected along the main road at both ends of Pumphandle to advise travellers that they are entering a well protection area. The gravel pit owner fenced the pit and put up a sign by the field office. Due to other commitments the Regional District Engineer was not able to evaluate alternatives for chemical road maintenance.

The regional district had drafted a by-law to require regular maintenance of septic systems. Their lawyers are reviewing the draft by-law.

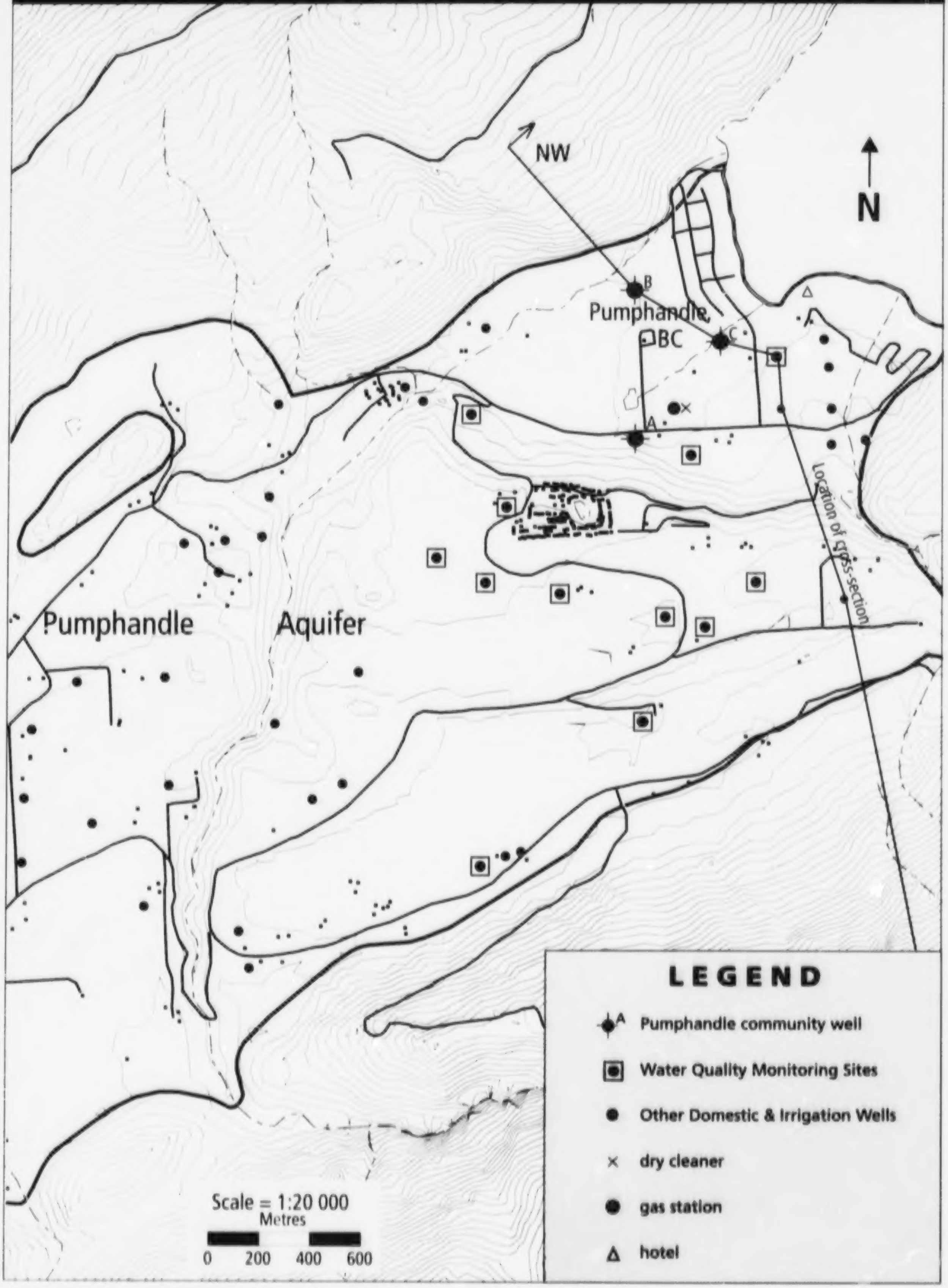
Monitor Water Quality

The planning team also developed a water quality monitoring program. The three community wells were sampled in the fall of the first year to establish baseline data. Tests were conducted for a comprehensive list of physical, inorganic and organic (volatile organic compounds (VOCs) and selected

[10] Nener, J. (1977). *Watershed Stewardship: A Guide for Agriculture*. Co-produced by the Government of British Columbia and the Government of Canada. 60pp.

[11] UMA Engineering Ltd. (1996). *Greening Your Golf Course: A Guide to Environmental Management*. Produced by Environment Canada and the Department of Fisheries and Oceans. 44pp.

FIGURE CS6.1: WATER QUALITY MONITORING SITES


NW
N
B
Pumphandle
BC
C
A
Location of cross-section
Pumphandle
Aquifer
LEGEND
A Pumphandle community well
Water Quality Monitoring Sites
Other Domestic & Irrigation Wells
dry cleaner
gas station
hotel
Scale = 1:20 000
Metres
0
200
400
600

pesticides), for a cost of about $950 per sample. Water quality of twelve private wells in the protection area was also sampled, specifically for Total Dissolved Solids, pH and nitrates at a cost of $50 per sample. Although pesticides and bacteria could also be present in the protection area, it was felt that these tests would not be necessary at this time in the private wells (see Figure CS6.1).

The planning team used the procedures from Ministry of Environment, Lands and Parks to collect the well water samples. The Ministry of Environment, Lands and Parks and environmental health officer provided technical advice and the field kit to assist with well water sampling. Two duplicate samples and one spiked nitrate sample were also collected to check the field nitrate analysis as part of a minimal quality assurance/quality control (QA/QC) program. A QA/QC program was seen as essential to obtain reliable results.

The water chemistry results detected no VOCs or pesticides in the three community wells. Elevated nitrate levels (above 3 mg/L NO_3-N) occurred in seven of the 15 wells sampled, including Aiken's Well. Sampling results were sent to well owners. Laboratory results were archived in the Ministry of Environment, Lands and Parks' EMS[12] database and a paper copy was sent to the planning team by the laboratory. The Environmental Health Officer reviewed the data and prepared a brief water quality monitoring report to summarize the results (this will be done annually).

Evaluate and Revise the Well Protection Plan

Overall, the planning team felt that good progress had been made. Part of the success was attributed to good communications within the small community, and high level of community input.

Modifications and plans for the coming year included:

- Continue to encourage the owner at A-6 to adopt BMPs and IPM next year;
- Ask neighbouring landowners and the golf course owner to track costs for BMPs and IPM, to assess the long-term cost savings from these measures;
- Approach the community for funds to pay 50% of the costs of grouting the abandoned well and sending the dry cleaner to the spill course. A community garage sale was suggested, as were car washes for raising funds;
- Continue to sample the network of private wells for monitoring ambient groundwater quality, at a cost of about $700 for laboratory analysis. Agreements will be developed with the landowners. Data collected will be plotted to establish water quality trends.
- Evaluate alternatives for chemical road maintenance.
- Continue the work by the regional district to develop draft by-laws to require environmental impact assessments prior to approving new developments.

Report on Progress

A year-end report will be produced to summarize the work during the first year. This will be presented at a public meeting, which will also be used to gather community input on activities for the coming year.

A 300-word mid-term progress report was drafted and included in the newsletter sent out by the regional district.

Celebrate Success

Aiken's Waterworks held the "first annual community well protection picnic" to celebrate the first year-end report.

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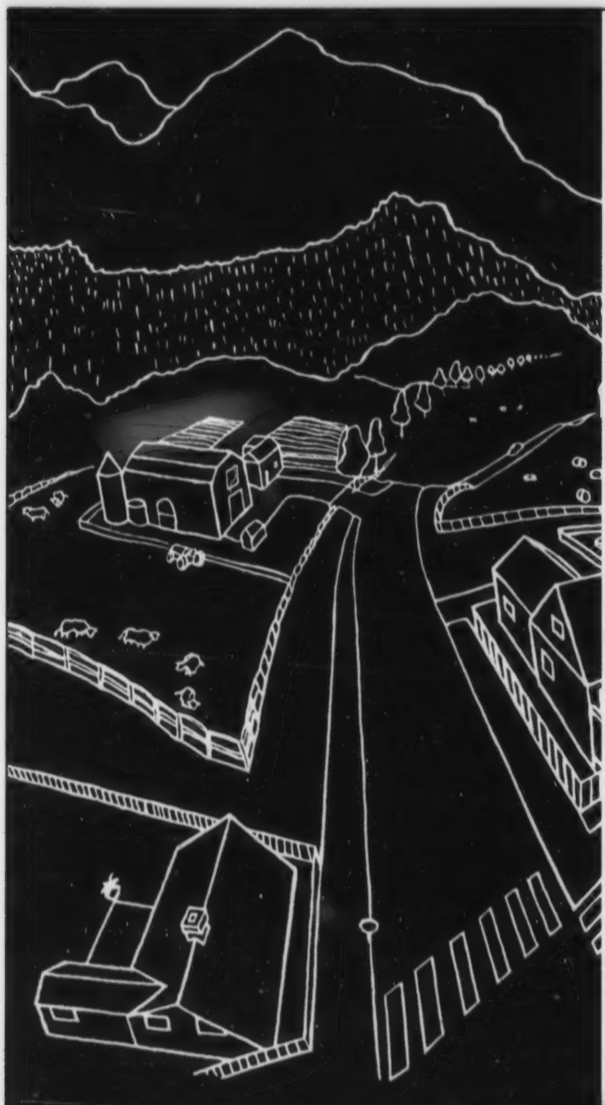
[12] Environmental Monitoring System



PUMPHANDLE WELL PROTECTION PLAN

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WELL PROTECTION PLAN FOR PUMPHANDLE, B.C.

MAY 1999

Prepared by the
Pumphandle Community Planning Team

Note: This Well Protection Plan for Pumphandle, B.C. *is provided as an example only, so the reader can get an idea of what might go into a well protection plan. It is not intended to be a template where a community can take it and simply "fill in the blanks." That won't work – developing a well protection plan will take a lot of time and effort. The plan will reflect the unique conditions and data for your community; it could be simpler (or more comprehensive) than this example.*

The Pumphandle Community Team was very efficient and effective in putting together this information in a very short time frame. Do not be alarmed if your community planning team takes longer to achieve the same outcome – each community is different.

Just in case your community is unsure about developing a plan, compare the cost of replacing your well system after it has been contaminated to the cost of developing and implementing a well protection plan. A plan will be worth the effort!

Acknowledgements

The community planning team would like to thank the residents and businesses of Pumphandle for their input and help in developing the well protection plan for their community, especially:

- The Geography 12 class of Valley High School for conducting the inventory survey;
- The Valley Regional District for their support and logistical help;
- The Pumphandle Valley Chamber of Commerce for their ongoing support and assistance in distributing educational materials throughout the community;
- The Ministry of Environment, Lands and Parks and Pumphandle Valley Community Health Services Society for technical assistance; and
- Jacqui Carboneau of Geoplan Inc. and Henrique Darcy of Hydro-Logic for their assistance in drafting the well protection plan.

Executive Summary

The *Well Protection Plan for Pumphandle, B.C.* was developed in response to rising nitrate levels in one of Pumphandle's three community wells, and the desire to protect the groundwater supply from possible contamination from a variety of sources.

In May 1998, members of the community formed a planning team to develop a well protection plan and oversee its implementation. The well protection plan takes a constructive approach to groundwater protection, focussing on prevention activities and offering solutions to current concerns. The objective of the well protection plan is to bring the community together to protect their drinking water supplies. The community planning team has identified those contaminant sources most likely to pose a risk to the water supply, and has prepared strategies to reduce the risk of groundwater contamination with input from the community. Contingency plans have also been developed to minimize the impacts of any unexpected contamination event. A program is in place to monitor water quality on a regular basis.

This initial well protection plan was developed using available financial and other resources. The results of the well protection plan will be evaluated annually, and the plan will be updated to reflect changing community needs and available funding.

For further information on the well protection planning process, please contact:

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Introduction

Pumphandle's Community Water Supply

Pumphandle, British Columbia is a small town with 650 residents, located in a valley to the east of Vancouver. Most of the drinking water is supplied from three community wells (Figure 1):

- Aiken's Well, shown as Well A, is a shallow well dug into a spring. Water from the well is supplied to the main subdivision in Pumphandle with 165 homes (500 residents), and a number of commercial users including a gas station and dry cleaner.
- The Blackwater Well, shown as Well B, supplies water to another 35 homes (100 residents), and the campground, hotel, schools and golf course.
- Charlie's Well, shown as Well C, provides water to a small new subdivision of 15 homes with approximately 50 residents.

A summary of the community wells is shown in Table 1. Note that for Aiken's Well, the demand exceeds the supply. Well assessment forms were filled out for all three wells and are included in Appendix 1.

Table 1: Summary of Pumphandle Community Wells

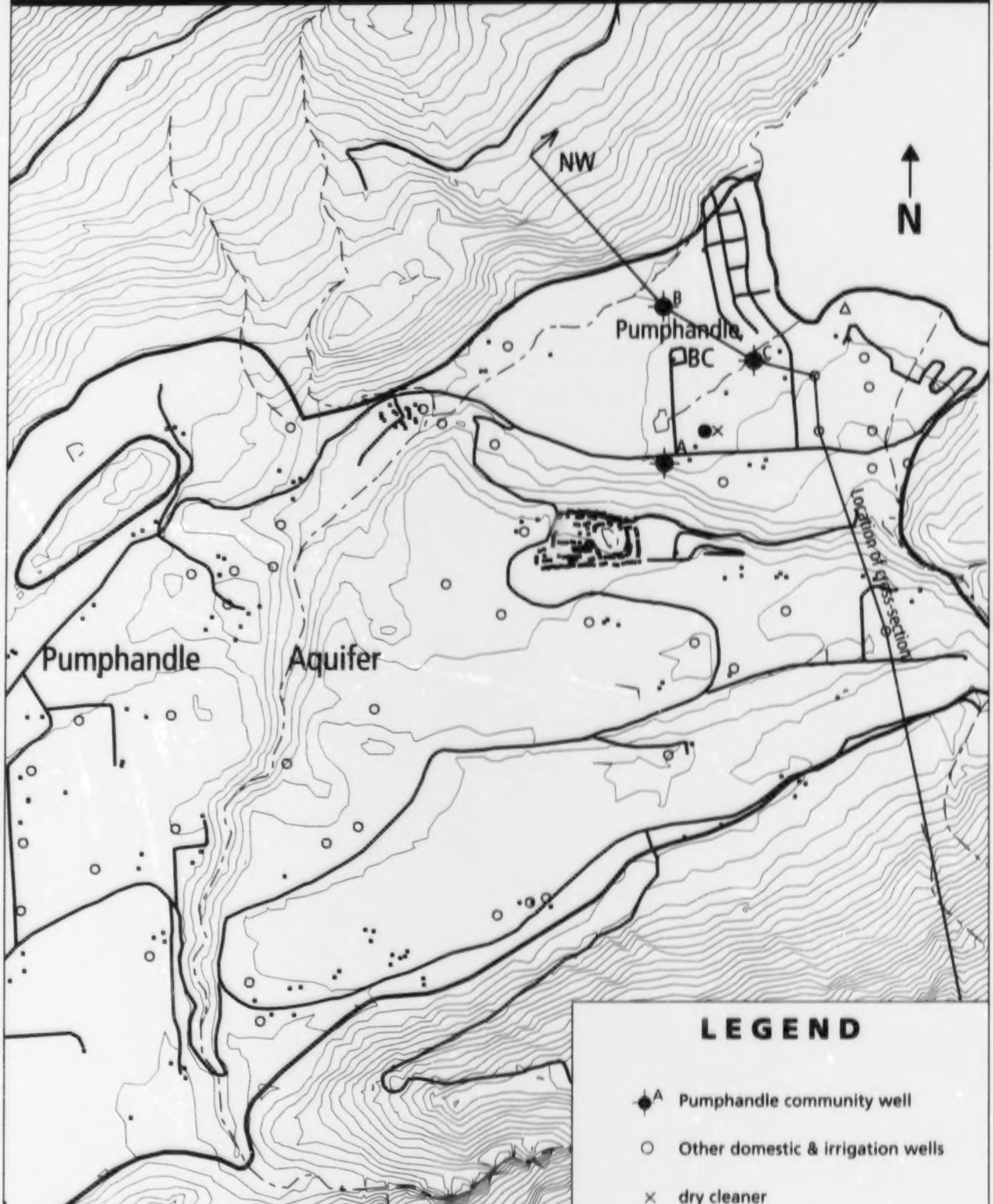
Well	Type	Depth (m)	Diameter (mm)	Rated Capacity (L/s)	Drinking Water Demand (L/s)	No. of users
Aiken	dug	2.4	915	5.10	5.26	500
Blackwater	drilled	30.5	200	22.73	1.05	100
Charlie	drilled	25.6	150	7.58	0.53	50

In rural areas around Pumphandle, and further up the valley, to the south and west of Pumphandle, residents rely on individual wells and private intakes into the nearby mountain creeks.

Water Quality Issues

In 1998, the purveyor for Aiken Waterworks discovered that the nitrate-nitrogen value for Aiken's Well had reached 7 mg/L. Nitrate-nitrogen levels in Blackwater Well and Charlie's Well were also elevated (4.2 and 3 mg/L, respectively). The regional health authority is required to shut down any well if the nitrate-nitrogen level reaches the Canadian drinking water guideline of 10 mg/L.

FIGURE 1: PUMPHANDLE'S WATER SUPPLY


NW
N
B
Pumphandle
BC
C
A
Location of cross-section
Pumphandle Aquifer
LEGEND
A Pumphandle community well
Other domestic & irrigation wells
dry cleaner
gas station
hotel
Scale = 1:20 000
Metres
0
200
400
600

Pumphandle has always relied on groundwater for its water supply. Although surface water supplies are locally abundant, both Pumphandle Lake and Pumphandle Creek would require treatment, which is expensive and undesirable to the community.

After comparing the cost of replacing their well systems to the cost of preventing contamination by developing and implementing a well protection plan, the purveyors of all three waterworks systems agreed that it would be more cost-effective to initiate a well protection plan immediately. The purveyors also agreed to lead the development of the plan.

1.0 The Community Planning Team

1.1 Membership

The three water purveyors approached Pumphandle Community Health Services Society and the Valley Regional District in March 1998 and received support to develop a well protection plan.

In May 1998, a community planning team was formed to oversee the development of the well protection plan. Membership of the team included:

- Andrew Aiken, purveyor for Aiken Waterworks' Well (team leader)
- Jenny Lowden, purveyor for Blackwater Waterworks' Well
- Eric Kowski, purveyor for Charlie's Improvement District Well
- Ian Rutherford, P.Eng., Engineer, Valley Regional District
- Simon Lee, farmer
- Jocelyne Dufour, campground owner/operator
- Devon Alexander, Pumphandle Valley Conservation Society
- Anne Jones, Environmental Health Officer, Pumphandle Community Health Services Society

The initial terms of reference of the community planning team stated that the community planning team should have at least five and no more than ten members. Membership should include one representative from each of the three water purveyors, one representative from the local health authority and a representative from the Valley Regional District.

The community planning team met regularly to develop this *Well Protection Plan*, using the provincial government's *Well Protection Toolkit* as a guide.

1.2 Goals and Objectives

The planning team and the stakeholders in the community have agreed that protecting their well water supply is important and that clean water is beneficial to the economic viability of this community. The goals and objectives for Pumphandle's *Well Protection Plan* are:

Goal 1: To encourage public awareness of the need to protect groundwater

Objectives:

- Produce an information sheet on the well water supplies in Pumphandle;
- Hold public information meetings;
- Conduct a groundwater issues survey;
- Place signs in strategic locations informing the public that they are in a designated well protection area;
- Include groundwater information in the public school education programs; and
- Raise money to assist with publication of educational materials.

Goal 2: To develop and implement a well protection plan that will minimize the nitrate levels in the Pumphandle wells and aquifer

Objectives:

- Complete the well assessment form for each community well;
- Delineate the well protection area for all three community wells;
- Conduct a contaminants inventory for all of Pumphandle;
- Select groundwater protection measures;
- Develop and implement a contingency/emergency response plan; and
- Design and implement a monitoring and evaluation program.

Members of the community planning team were assigned tasks for meeting these objectives.

2.0 The Well Protection Area

2.1 The Pumphandle Aquifer

All three community wells and private wells in the area draw groundwater from the Pumphandle aquifer. Hydro-Logic Groundwater Consultants were hired to assess the hydrogeology of the Pumphandle area and to define the preliminary capture zones for the community wells. The hydrogeology of the local area is summarized as follows:

- The Pumphandle aquifer is a sand and gravel aquifer that underlies the community and the valley to the south-west;
- The aquifer is quite productive, able to supply groundwater to wells at rates of up to 25 L/s;
- The aquifer is highly vulnerable to contamination in the Pumphandle area because there is no clay or till layer above it (the aquifer is unconfined) and the water table is within a few metres of the land surface.

More information on the Pumphandle aquifer and the hydrogeology is contained in the consultants' report in Appendix 2.

2.2 Capture Zones

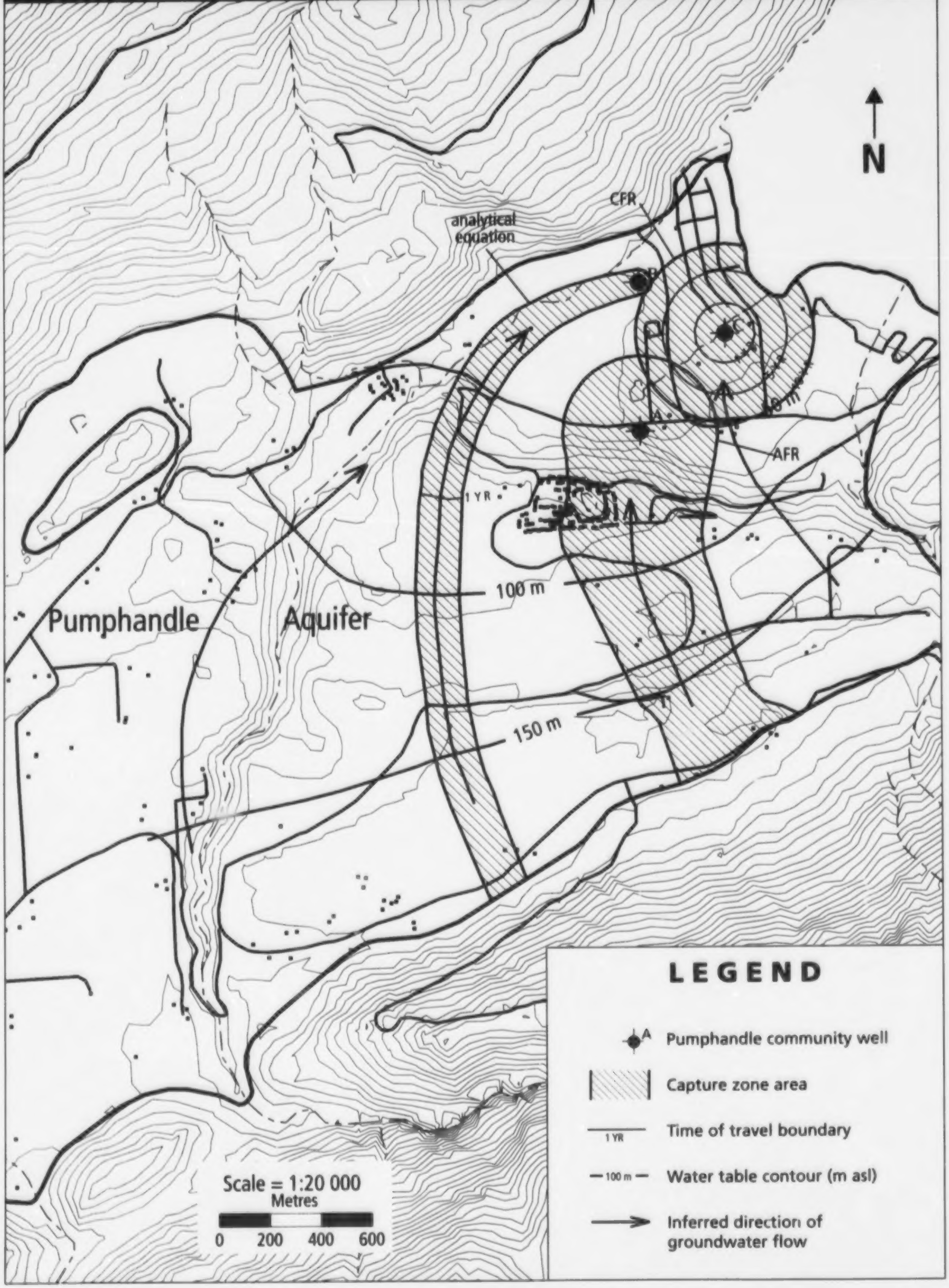
The consultants used the hydrogeologic information, along with the pump test and water consumption data from the three water districts, to define the probable capture zones for the three community wells (Figure 2 and Table 2).

Table 2: Capture Zone Areas

Community well	Capture zone area (hectares)
Aiken	80
Blackwater	46
Charlie	38

The Time of Travel (TOT) for water in the capture zones to flow to the community wells is also shown in Figure 2. The TOT for Aiken's Well could not be determined because of insufficient data. The capture zones were identified using available information and simplistic assumptions about the hydrogeology, so there is some uncertainty related to the actual size and location of the capture zones. Despite this uncertainty, the delineation of the capture zones is reasonable based on the available information and the consultants' evaluation of the data.

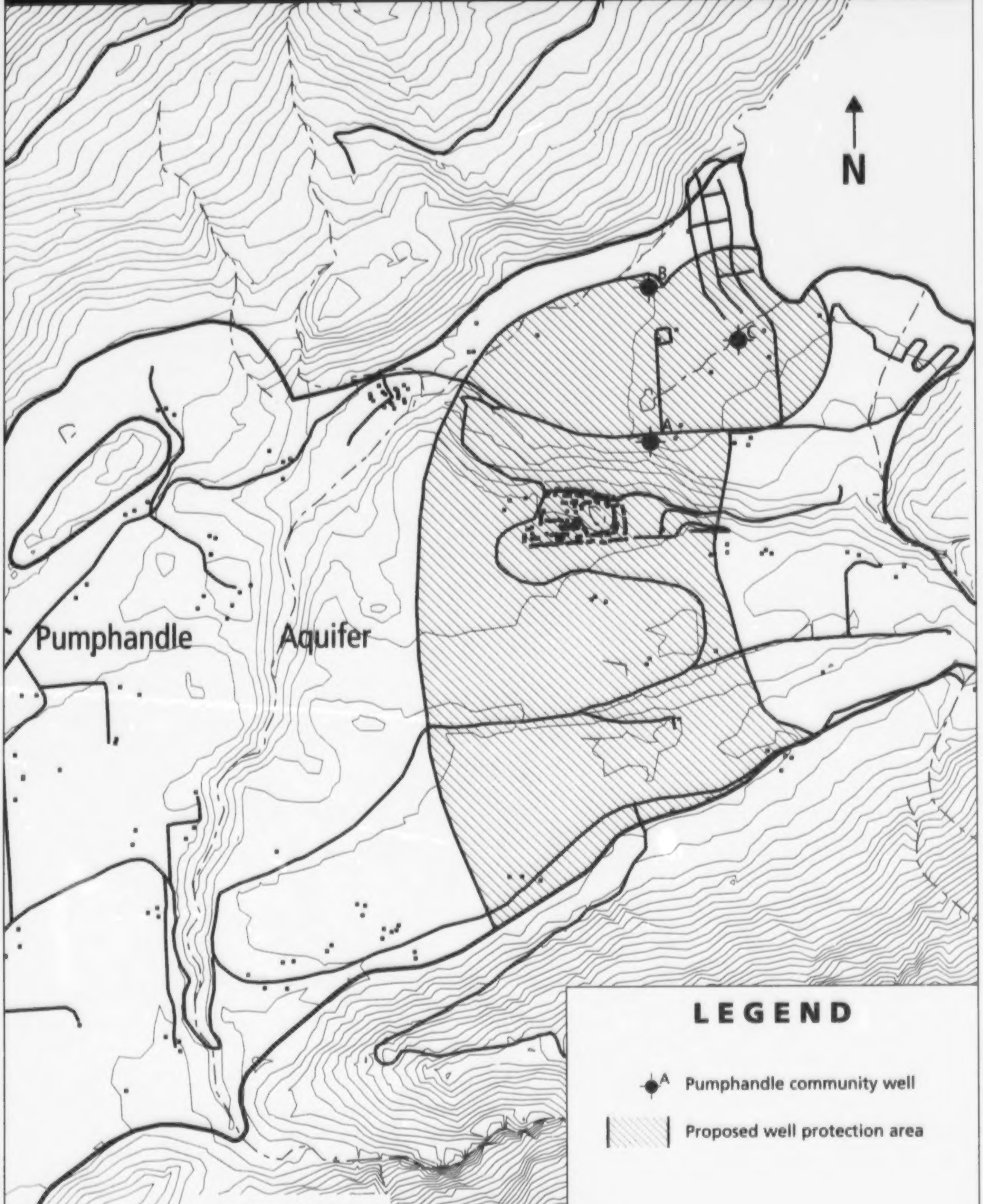
FIGURE 2: CAPTURE ZONES FOR COMMUNITY WELLS


N
CFR
analytical equation
B
C
A
AFR
10 m
1 YR
100 m
150 m
Pumphandle
Aquifer
LEGEND
A Pumphandle community well
Capture zone area
1 YR Time of travel boundary
100 m Water table contour (m asl)
Inferred direction of groundwater flow
Scale = 1:20 000
Metres
0
200
400
600

2.3 The Well Protection Area

Because of the uncertainty related to the size and location of the capture zones, the community planning team have included the area in between the capture zones as part of the well protection area. This well protection area covers a total of 261 ha and occupies the immediate uphill area from the wells (Figure 3). Much of the well protection area lies beyond the boundary of the three water districts, in areas managed by the Regional District.

FIGURE 3: PROPOSED WELL PROTECTION AREA


N
B
C
A
Pumphandle
Aquifer
LEGEND
● A Pumphandle community well
▨ Proposed well protection area
Scale = 1:20 000
Metres
0
200
400
600

3.0 Sources of Potential Contamination

3.1 Results of Surveys

The Geography 12 teacher and students from Valley High School conducted a contaminant inventory as a school science project. The students used air photos and soil maps, interviews with staff from the Ministry of Environment, Lands and Parks and the Pumphandle Community Health Services Society, and surveys/site inspections to gather information.

The land uses and potential contamination sources were mapped on a 1:20,000 scale map (Figure 4) and land use practices were documented in an Excel spreadsheet (Appendix 3). Potential contaminant sources include:

- Fertilizers (nitrate) and pesticides from farms, residential areas, corn field and the golf course;
- The poultry barn on A-3 (nitrate);
- Septic systems (nitrate) and household hazardous wastes (solvents, paints, fertilizers and pesticides) from residential areas;
- The gas station (hydrocarbon chemicals);
- The dry cleaner (drycleaning chemicals);
- An abandoned well on A-3; and
- The main road (accidental spills).

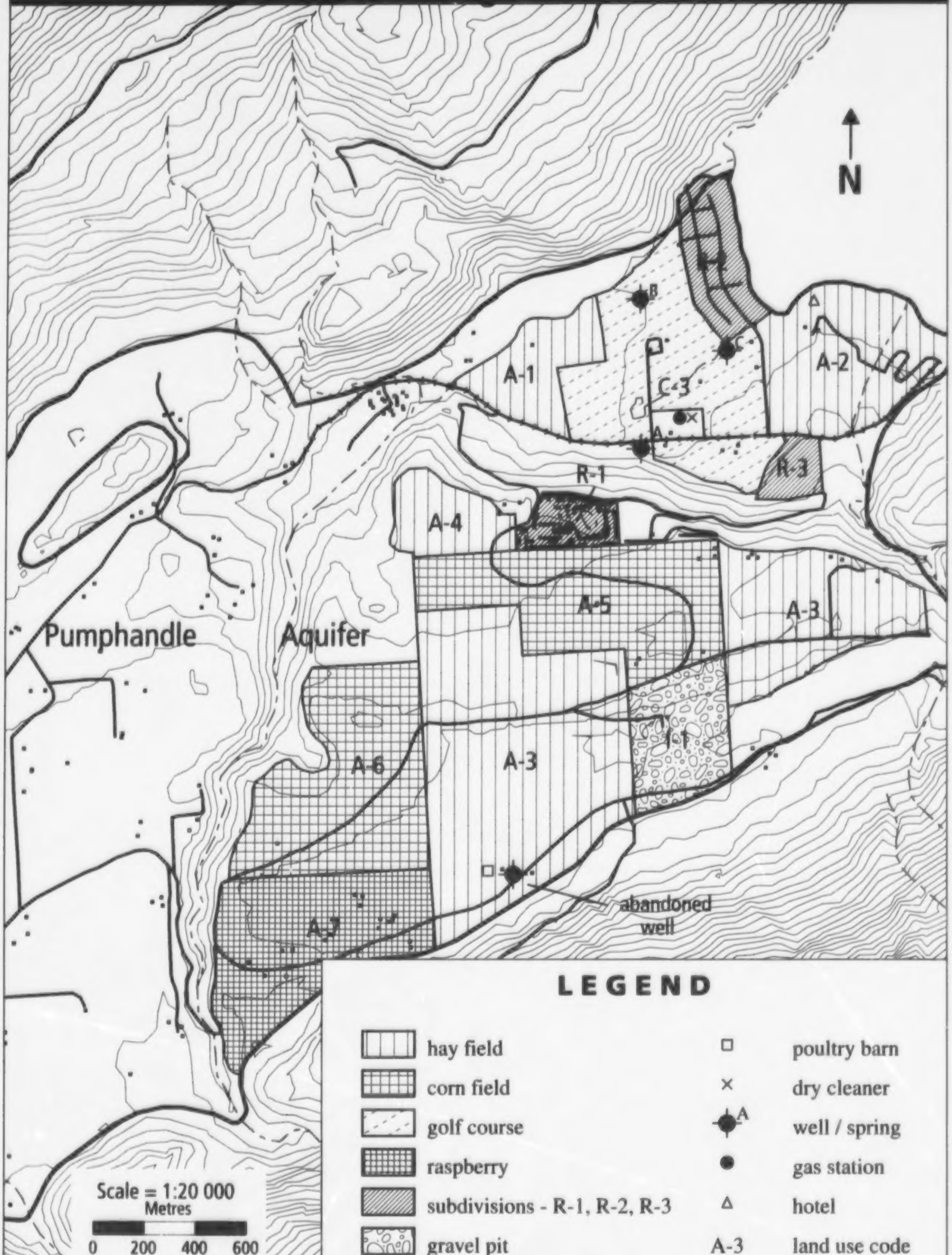
Bacteria and viruses from septic systems are not considered a serious threat. Despite the large number of septic fields uphill of Aiken's Well, there is regular testing for bacteria and none has been found in any of the well water supplies.

3.2 Priorities for Action

The community planning team set priorities for action according to the proximity of a source to a community well (high priority for potential sources located within the one-year time of travel from a community well) and possible consequences of contamination.

> **The highest priority sources include the golf course (C-3), gas station (C-1), dry cleaner (C-4) and subdivisions (R-1 and R-2), a corn field (A-5), hay fields (A-1 and A-4), and the main road (T-1).**
>
> These sites are all within the one-year time of travel zone for at least one of the wells, or are close to one of the wells. These land use activities are associated with potential sources of contamination such as septic fields, pesticide and fertilizer applications, solvents and gasoline storage, or the consequence of any contamination would be severe. The main road is also a potential contamination source from accidents or from use of de-icing chemicals in the winter.

FIGURE 4: LAND USES IN PUMPHANDLE


N
A-1
A-2
A-3
A-4
A-5
A-6
A-7
C-3
R-1
R-2
R-3
I-1
A
B
C
Pumphandle
Aquifer
abandoned well
LEGEND
hay field
corn field
golf course
raspberry
subdivisions - R-1, R-2, R-3
gravel pit
poultry barn
dry cleaner
well / spring
gas station
hotel
A-3
land use code
Scale = 1:20 000
Metres
0
200
400
600

The lower priority sources include the other corn/hay fields (A-2, A-3, A-6), gravel pit (I-1), hotel (C-2)and the poultry barn (A-3) and abandoned well (A-3).

The corn/hay fields and gravel pit were rated as a lower priority since they are located further from the well sources. The community planning will work with the owners to promote Best Management Practices. The abandoned well and poultry barn are located beyond the one-year TOT from the community wells.

The community planning team will review the land uses and practices and update the database and land use map annually. Data from the contaminant survey were initially entered and stored in a spreadsheet in MS-Excel. The data have now been uploaded to the Valley Regional District's geographic information system (GIS).

4.0 Management Options

4.1 Assessing Options

A public meeting was held at the fire-hall on September 21st 1998, to present findings of the contaminant survey. About 30 stakeholders and members of the community planning team discussed and identified possible management options for every potential contaminant source, and listed the agencies with the authority to control activities.

The participants used the S*M*A*R*T test[1] to assess the suitability of each possible option. The options that passed the S*M*A*R*T test are shown in Appendix 4. From the list of options, a two-year implementation schedule was developed (Appendix 5). Options were also developed for some of the lower priority sources of potential contamination because solutions can be easily implemented.

4.2 Proposed Actions

The actions for the period 1999-2001 include:

4.2.1 Non-regulatory Measures

- Simon Lee (farmer) and the purveyors will meet with the other farmers and the golf course operator to promote the use of Best Management Practices (BMP) and Integrated Pest Management (IPM). This will minimize use of pesticides and fertilizers. Soil testing will be carried out to more accurately determine fertilizer requirements. Simon and the purveyors will also talk to the farmers and the golf course operator about the importance of regularly maintaining their septic systems.
- Anne Jones, the Environmental Health Officer, will encourage the owners of the gas station and dry cleaner to attend a spill response course in Vancouver ($400 for course and expenses). Funds could be raised by adding a 4% surcharge to customers. Anne will review the dry cleaning operations and, if required, work with the owner to identify and adopt improved practices.
- The Regional District will develop a public education program. They will work with the Pumphandle Valley Conservation Society and purveyors to prepare a two-page newsletter on the proper use, storage and disposal of garden fertilizers, pesticides, and other household hazardous wastes. This will be mailed with the water bills to all residents in the region, at a cost of $200 for production and mailing. To raise the funds to do this, the Conservation Society plans to hold two car washes.
- Anne Jones will talk to the owner of A-3 about grouting off his abandoned well to prevent contaminants from directly entering the aquifer. The well would be abandoned according to the draft *Code of Practice for Construction, Testing, Maintenance, Alteration and*

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[1] S*M*A*R*T refers to Specific, Measurable, Achievable, Realistic and Time-bound, and is a method for deciding the most effective options.

Closure of Wells, Province of British Columbia. Cost for hiring a local well driller to do this is about $1,000, which the owner will have to fund.

- Valley Regional District will pay for and erect signs at two locations along the main road to advise people that they are entering a well protection area. The Regional District will allocate this amount ($600) out of next year's budget.

4.2.2 Regulatory Measures

- Staff from the local Ministry of Environment, Lands and Parks have agreed to place a priority on enforcing the Agricultural Code of Practice over the entire aquifer in the Pumphandle Valley. This includes the handling of manure and other agricultural waste for the poultry barn on A-3 and on the other farms.
- The Regional District has agreed to consider new by-laws to require private and community septic systems to be maintained on a regular three-year basis, and to restrict the quantity of dry cleaning chemicals in the protection area. Staff will also work towards a third by-law, that would require that any new subdivision development in the well protection area identify and address potential impacts on the groundwater.
- Ian Rutherford will contact the Ministry of Energy and Mines to seek their support for revisions to the permit for gravel extraction at I-1. The proponent would be required to erect a fence and put up signs around the gravel pit prohibiting the dumping of garbage.

The progress of these actions will be discussed at monthly community planning team meetings to make sure progress is being made and to identify any problems encountered.

5.0 Contingency Plans

5.1 Possible Contamination Events

The community planning team reviewed all the potential sources of contamination and the Emergency Response Plan for each of the water systems. They then developed "what if" scenarios (contingency activities).

Possible contamination events are identified in Appendix 6. The most likely events are:

- Routine monitoring detects contamination in the groundwater; or
- The planning team receives reports of chemical spills, discharge or bad practices within the well protection area (or directly into a well).

The contaminant most likely to affect any of the community wells is nitrates from either fertilizers or septic wastes.

The existing Emergency Response Plans (developed by the three purveyors) contain standard operating procedures (SOPs) that deal with such issues as the contamination of the water system through water main breaks or back flow of contaminated water, and the loss of supply either from pump breakdown or power failure. These SOPs form an integral part of the Contingency Plan. Additional SOPs have been developed to address the most likely scenarios. Local physicians and pharmacies have been asked to alert the planning team if there is an increase in physician visits for diarrhea, or in sales of anti-diarrhea medicine.

5.2 Resources Available to Respond to Spills

A list of resources required for emergency response has been developed, and the necessary supplies are stored at Blackwater Waterworks.

This listing identified several resource items that are not currently available in Pumphandle:

- Sorbent materials for dealing with spills;
- Alternate water supplies (short term supply);
- Emergency chlorinator and attachment sites;
- Protocols for fire-fighting at the dry cleaners and gas station that would minimize spread of contaminants to the aquifer;
- Access to wells for monitoring (existing private wells located between community supplies and potential contaminant sites); and
- Rental agreement with AAA Excavation Services.

The following actions have been taken in response:

- The purveyors have purchased additional sorbent materials, which are stored at the Blackwater Waterworks. These would be available to any of the water purveyors should a spill occur.
- Arrangements have been made with Barney Buhler of Barney's Bulk Water Service in Valleyview. Barney has agreed to provide priority service to Pumphandle and its residents in case of an emergency, and the volunteer fire department will help to distribute the water to the residents. Barney will also coordinate and supply bottled water from his brother's bottling plant in Valleyview.
- The three water purveyors will cost share in the purchase of a chlorinator and install fittings at each of the three well heads to allow the chlorinator to be attached should a well become contaminated with pathogens. AAA Excavation Services in Valleyview will supply equipment for excavation work in the case of an emergency. Each water purveyor has a list of pumps, sump-pumps, piping and other waterworks supplies available in case of an emergency situation. Each water purveyor has on-site generators capable of powering their pumps in case of an electrical service failure.
- Fire-fighting protocols have been developed. The local R.C.M.P. detachment, Pumphandle Volunteer Fire Department, the Ministry of Environment, Lands and Parks and the local health authority will act as first responders to contamination events.
- Agreements are being developed with private well owners to use their wells for monitoring purposes.

Each water purveyor has:

- A copy of their emergency plan and the contingency plan for Pumphandle Valley;
- A list of resources required/available for emergency response;
- A master list of phone numbers of agencies and individuals who can respond to the various scenarios, including emergency situations; and
- A map of the distribution systems with valves locations and drawings of the well head for each water system.

5.3 Contingency Activities

The scenarios of how the well water supplies can be contaminated due to unplanned accidents or from events beyond control are listed in Appendix 6. Six short-term contingency activities have been identified:

- Contain and/or clean spill and contaminated soil;
- Determine public health significance of contaminant;
- Issue public advisories;
- Provide alternative water supply;

- Expand monitoring program to determine if other contaminants are present and to identify the source and extent of contamination; and
- Chlorinate water supply.

Public advisories have been drafted. If a public advisory is needed, any specific concern such as unsatisfactory bacteria tests or nitrate contamination can be written into the draft. When a public advisory is needed, press releases will be sent to the Pumphandle community newspaper and the Valley Radio Station, and notices delivered directly to individual homes.

5.4 Future Requirements

Contingency planning identified the need for a long-term alternate water supply (new well), and additional funding to purchase emergency equipment and supplies. These needs are beyond the ability of the planning team to arrange on a short-term basis, and the planning team will be asking the Valley Regional District for assistance.

The Blackwater Well is the least vulnerable as it is located farther from most potential contaminant sources. It is deeper than Aiken's and Charlie's Wells, and produces the greatest amount of water. One option is to connect the three community water supplies so that Blackwater Well can supply water to all residents in an emergency. This would be especially beneficial since the peak use demands on Aiken's Well already exceed supply. Some of the costs of connecting the three distribution systems would be offset by the cost saving of not drilling a new well to replace Aiken's Well. The purveyors will conduct cost-benefit analyses on connecting the Blackwater Well to the other two water systems, versus having Aiken Waterworks drill a new well close to their present source. They will apply to the Ministry of Municipal Affairs for funding for a planning grant to evaluate these options.

6.0 Monitoring and Evaluation

6.1 Monitoring Water Quality

6.1.1 Sampling Procedures

Monitoring private wells allows for the early detection of contamination before it reaches any of the community wells. Water quality monitoring will include monitoring at Pumphandle's three community wells, and at a network of private wells (Figure 5).

Samples will be collected as follows:

- Each well will be sampled once a year in the fall.
- Two teams will be established so sampling can be completed in one day.
- Sampling will be completed and shipped before Friday.
- Samples will be collected at mid-day after the pumps have been on for a few hours and shipped directly to the Chemtest Laboratory in Vancouver for analysis.
- All samples will be collected at the source in the pump houses.
- Sampling procedures for each well will be documented on the *Water Quality Sampling Form* (Appendix 7). This will be done for every well and each time a well is sampled.

The sampling team will use sampling procedures from the Ministry of Environment, Lands and Parks (see Appendix 8). The three water districts will each contribute $600 to purchase equipment for field analysis. The equipment will include a conductivity meter, nitrate kit and pocket pH meter.

Community wells: The three community wells will be sampled every fall to establish baseline data, starting in 1999. The well samples will be tested for a comprehensive list of physical, inorganic and organic constituents at a cost of $950 per sample. The parameters are listed in Appendix 9.

The three wells will continue to be sampled on a weekly basis for fecal coliforms and total bacteria. Cost of bacteriological sampling is $20 per sample. The total annual cost for water quality sampling for the three Pumphandle community wells will total $7,220, including Quality Assurance/Quality Control (QA/QC) samples (see Table 3).

Private wells: Water quality of twelve private wells in the protection area will be sampled specifically for Total Dissolved Solids, pH and nitrates at a cost of $50 per sample. If the nitrate-nitrogen levels in the wells increase beyond 8 mg/L, pesticides will be included in the analysis. Cost for sampling the private wells will total $700 per year, including one duplicate and one spiked sample (Table 3).

FIGURE 5: WATER QUALITY MONITORING SITES

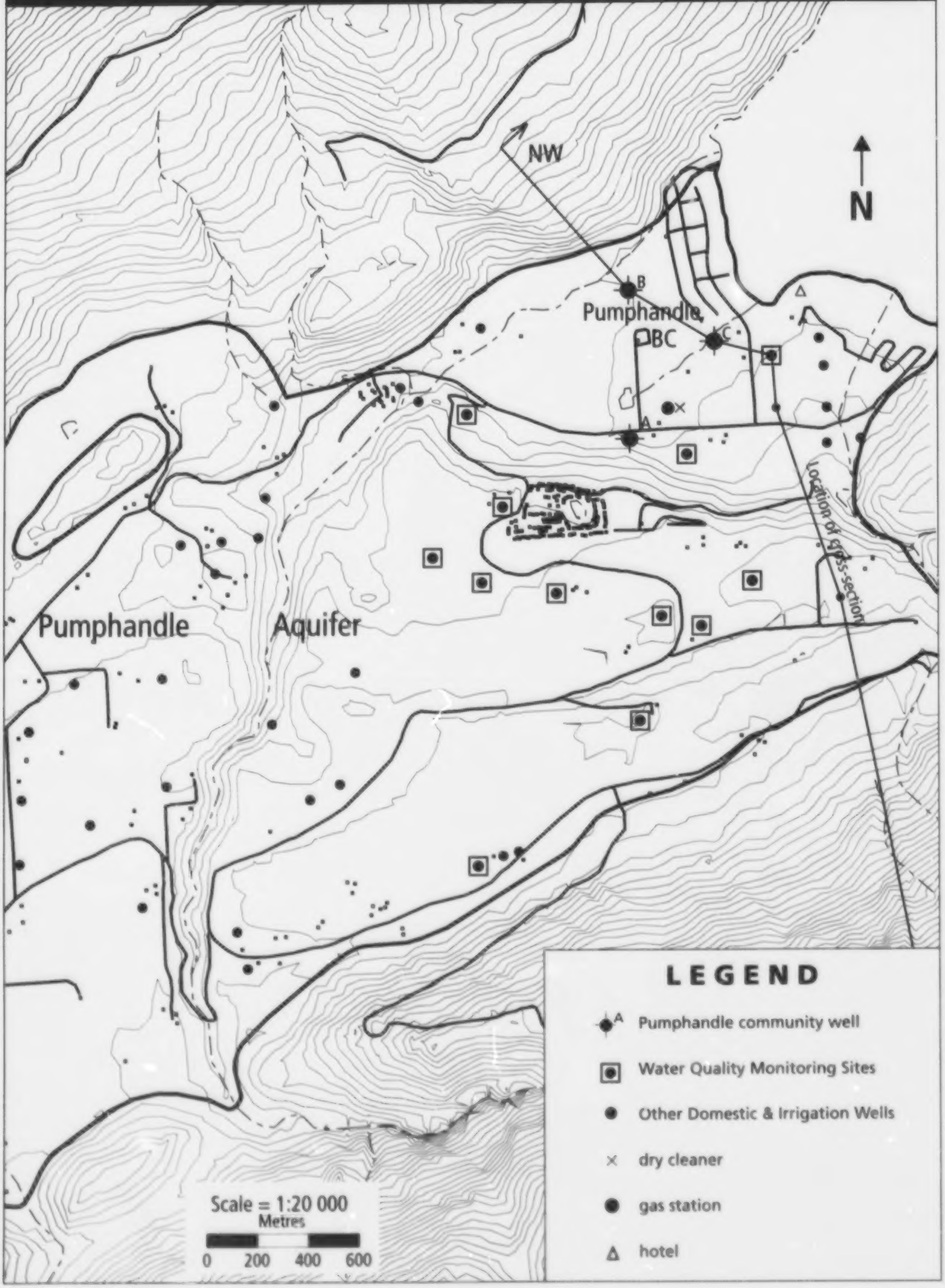

NW
N
B
Pumphandle
BC
C
A
Location of cross-section
Pumphandle Aquifer
LEGEND
Pumphandle community well
Water Quality Monitoring Sites
Other Domestic & Irrigation Wells
dry cleaner
gas station
hotel
Scale = 1:20 000
Metres
0
200
400
600

Table 3: Summary of Water Quality Sampling Costs

Wells	Number of samples	Number of QA/QC samples	Cost per sample	Total Cost	Paid by:
3 community wells	3 annual samples for comprehensive analysis	1 duplicate	$950 in first year; $250 for subsequent years	$3,800; $1,000 for subsequent years	Local health authority in first year; water districts after that
	156 weekly samples for bacteriological analysis	15 duplicates	$20	$3,420	Local health authority
12 private wells	12 annual samples for TDS, pH, & NO_3-N analysis	1 duplicate 1 spiked	$50	$700	Water districts
Total costs				$7,920 for first year, then $5,120 per year	

6.1.2 Recording Information

The Ministry of Environment, Lands and Parks has agreed to establish files for the three community wells and the twelve private wells in their Environmental Monitoring System (EMS) database. The sampling teams will record the EMS number in the requisition forms that are submitted to the laboratory with each sample. All water quality data analyzed by the laboratory will be automatically uploaded and archived into the database. The data for these wells can be downloaded at any time.

6.1.3 Quality Control/Quality Assurance

Ministry of Environment, Lands and Parks staff will train the sampling team. Mark Preston of the Ministry will accompany the teams during sampling to audit their technique in the first two years. Two random duplicate samples – one of a community well and one of a private well – and one spiked nitrate sample of a private well will also be collected to check the laboratory analyses as part of a minimal QA/QC program. Duplicate samples for bacteriological analysis will also be collected during weekly sampling of community wells. The total annual cost for QA/QC will be $1,350.

Upon receipt of the water chemistry results in the mail, the sampling team will immediately check for any unusual results or results greater than the value (exceedances) found in the drinking water guidelines and call the laboratory for clarification if required.

As part of the QA/QC program, one member of the sampling team will also request funding to travel to the upcoming B.C. Water and Waste Association conference in Kelowna, and attend the workshop on Water Quality Interpretation as part of their on-going training.

6.1.4 Water Quality Reporting

The sampling team, with the help of the environmental health officer, will review the data yearly and prepare an annual water quality monitoring report to summarize the results (this will be done annually). The two-page report will contain:

- a brief description of the water quality results;
- a report on any exceedances in drinking water guidelines;
- a map of the Pumphandle area showing the wells being monitored, exceedances, nitrate-nitrogen levels, or any other relevant parameter;
- a graph of the nitrate-nitrogen (and any other relevant parameter) over time; and
- a discussion of actions to address water quality issues.

The annual water quality report will be approved by the community planning team and distributed with the water bill in January. The committee will also submit an article to the local newspaper about the water quality monitoring for the year.

The cost for for photocopying 250 reports for mail-out will be about $250.

6.1.5 Funding for Water Quality Monitoring

The total cost of water quality sampling is $7,920 per year for the first year and $5,120 for subsequent years, excluding volunteer time provided by the sampling team.

The three water districts have approvals from their Boards of Trustees for a $12 per connection surcharge per year ($1 / month for every connection) to raise $3,100 annually for the water quality monitoring program. This fund will be available starting next year and will be a continued source for water quality monitoring. Funds from this will pay for the sampling (except ongoing bacteriological sampling that is paid for by the local health authority) and reporting.

The local health authority will pay for the bacteriological and initial comprehensive analyses.

6.2 Evaluating Well Protection Activities

There are a number of management options to be implemented in the first year of the well protection plan. All of these will be evaluated to assess whether or not they were effective.

6.2.1 Agricultural Land and Golf Course

Follow-up interviews will be conducted with all the farmers and the manager of the golf course to see if fertilizer and pesticide practices have improved. Surveyors will ask about the type and amount of fertilizer used, when it was applied, and irrigation practices. They will inspect to verify that fertilizers and pesticides are properly stored.

Jim Summer, the farmer on A-3, will notify the committee when he intends to grout the abandoned well so members of the planning team can be on site to see how the well is sealed.

Levar Bocken of the Ministry of Environment, Lands and Parks will be in the area several times in the winter and spring to inspect how poultry wastes in the Pumphandle Valley are being managed. Levar will notify the community planning team if there are any breaches of the Code of Practice on lot A-3.

6.2.2 Trailer Park and Subdivisions

The Pumphandle Valley Conservation Society will design a survey to evaluate the awareness of groundwater protection amongst the local residents. This will be distributed to the residents at the trailer park and subdivisions. The survey will also ask the residents how they store and dispose of household hazardous wastes and if they participate in recycling programs.

6.2.3 Gas Station and Dry Cleaner

Anne Jones will speak with the owner of the gas station in the fall to check the results of the testing the gasoline tanks for leaks.

Anne will also speak with the owner of the dry cleaner to see how chemicals are stored and handled and to review the Code of Practice for implementation. Anne will ask the dry clean operator and gas station owner if they have taken the spill response course in Vancouver.

6.2.4 Eco-friendly Road Maintenance Program

Ian Rutherford, the engineer for the Regional District, will work with his staff to identify alternatives for road maintenance that will require less use of chemicals. He will present these alternatives at a community planning team meeting at year end and make a proposal to the Regional District to implement practical alternatives for the following year.

6.2.5 Signage on Roads and in the Gravel Pit

The Regional District and Greg Quaig, manager of the gravel pit, will inform the community planning team when they have erected the signs about aquifer protection along two locations on Pumphandle Highway and in the gravel pit. Ian Rutherford will provide up-dates on signage on Pumphandle Highway. Ian Rutherford will also contact Greg about progress of signage at the gravel pit. The effectiveness of the road signs will be evaluated by the number of phone calls received requesting more information and by including a question in the questionnaire survey to residents about whether the sign made a difference in reminding them of what their practices can do to the underlying groundwater.

6.2.6 Public Education

The Regional District will send the Conservation Society's survey questionnaire to rural residents to check the effectiveness of the public education efforts.

6.2.7 By-law Changes

The community planning team will follow-up on the proposals made to the Regional District for a by-law requiring residents to regularly maintain their septic system and a by-law to limit the quantity of drycleaning chemicals in the protection area and seek a response from the Regional District about their proposal.

6.2.8 Goals and Objectives

The community planning team will review their goals and objectives in April 2000 and prepare a summary of actions to date. At this time, the goals and objectives will be reviewed and adjusted as necessary.

BRITISH COLUMBIA
Ministry of Health and Ministry Responsible for Seniors
Ministry of Environment, Lands and Parks

WELL ASSESSMENT FORM

TO BE USED WITH THE WELL PROTECTION TOOLKIT.

IMPORTANT! Please complete one form for each ground water source used in your water system. Fill in available information. If missing information, it may be advisable to contact the Ministry of Environment, Lands and Parks' Groundwater Section [(250) 387-1115], or the local driller who drilled the well, to assist. Photocopy this form as necessary.

PART I: WELL SYSTEM INFORMATION (Refer to Step 1)

WATER SYSTEM LEGAL NAME: AIKEN'S WATERWORKS DISTRICT
LEGAL DESCRIPTION OF WELL LOCATION: PL 54914, SEC 10, TP22, NEW WEST

WATER SYSTEM LEGAL ADDRESS: 1775 PUMPHANDLE HWY., PUMPHANDLE, BC

LATITUDE / LONGITUDE: —
HOW WERE LOCATION COORDINATES DETERMINED? ☐ GPS ______ *(specify accuracy)* ☐ survey ☐ digitized from ______ map *(specify scale)*

UTM COORDINATES: E:571900; N:5431380
HOW MANY OTHER WELLS MAKE UP THE WATER SYSTEM? 1
DOES THE WATER SYSTEM ALSO USE A SURFACE WATER SOURCE? *(describe)* NO

NUMBER OF CONNECTIONS: Maximum 200 Actual 200
POPULATION SERVED: 500
WATER USE: ☒ domestic ☐ irrigation ☐ commercial ☐ industrial other *(specify)* ______

WIN NO. 52649
EMS NO. E218117
WELL TAG NO. —

Contact your local Ministry of Environment, Lands and Parks office or local Health Unit for the following information:
WIN NO. = MoELP's metal tag affixed to the well for on-site identification.
EMS NO. = MoELP's site number for the water chemistry on their database.
BC WELL TAG NO. = MoELP's computer number for the well

Bulk supply ☒ yes ☐ no
Back-up supply ☐ yes ☒ no
Emergency supply ☐ yes ☒ no
Metered ☒ yes ☐ no

WELL OWNER / OPERATOR INFORMATION
WELL OPERATOR: ANDREW AIKEN
WELL OPERATOR'S PHONE NO. (604) 853-4678
WELL OPERATOR'S ADDRESS: 1775 PUMPHANDLE HWY., PUMPHANDLE, BC
WELL OWNER: ANDREW AIKEN
WELL OWNER'S PHONE NO. ( ) AS ABOVE
WELL OWNER'S ADDRESS: AS ABOVE

PART II: WELL CONSTRUCTION INFORMATION (Refer to Step 1)

WELL-DRILLER'S NAME, COMPANY AND ADDRESS: N/A
POSTAL CODE: —
WELL-DRILLER'S TELEPHONE NO. ( ) —
DATE WELL ORIGINALLY CONSTRUCTED (YYYY MM DD): 1962 07
DATE OF LAST RECONSTRUCTION (YYYY MM DD): 1962 07

TYPE OF WELL: ☐ drilled ☒ dug ☐ other *(specify)* ______
METHOD OF DRILLING: ☐ rotary ☐ cable tool ☐ driven ☐ jetted ☐ other *(specify)* ______
WELL LOG AVAILABLE? ☐ yes *(attach)* ☒ no

DEPTH OF WELL: 2.4 m or 7.9 ft.
DIAMETER OF WELL: 1 m or 36 in.
SCREEN LENGTH: — m or — ft.
DEPTH TO TOP OF SCREEN: — m or — ft

WELL CAPACITY: 5.10 L/s or 67 Igpm
LOCATION OF WATER-BEARING FRACTION(S) (for bedrock wells): —
YIELD OF WATER-BEARING FRACTION(S): — L/s or — Igpm

WELLHEAD ENCLOSURE: ☒ pump house ☐ manhole ☐ other *(specify)* ______ ☐ none
SURFACE SANITARY SEAL: grouted to — m or — ft. ☒ no surface seal ☐ pitless adapter

AVERAGE PUMPING RATE: 5.10 L/s or 67 Igpm
HOW WAS PUMPING RATE DETERMINED? AVERAGED FROM ANNUAL VOLUME
DEPTH OF INTAKE SETTING: 2.2 m or 7.2 ft
PUMP AGE: 6

ANNUAL VOLUME OF WATER PUMPED: 160833600 or 35400000
HOW WAS VOLUME PUMPED DETERMINED? METERING RECORDS FROM 1993-1998

PUMPING CAPACITY: 5.30 L/s or 70 Igpm
ANY CHANGES OR REPAIRS MADE TO THE PUMPING EQUIPMENT? *(specify)* REPLACED PUMP IN 1992

TYPE OF STORAGE: ☒ tank(s) ☐ reservoir ☐ other *(specify)* ______
STORAGE CAPACITY: 46500 L or 10,000 Igal
COMMON INLET OR OUTLET? ☐ yes ☒ no

ATTACHED INFORMATION: ☐ well log ☐ drawings ☐ reports ☐ pump test data ☐ water quality data

NOTE: *If no well log is available, please attach any other records documenting well construction (i.e., "as built" drawings, engineering reports).*

PART III: HYDROGEOLOGIC INFORMATION (Refer to Steps 1 and 2)

DEPTH TO PUMPING WATER LEVEL 1.25 m or 4.1 ft.	DEPTH TO NON-PUMPING WATER LEVEL 0.3 m or 1 ft.	HOW WAS WATER LEVEL MEASURED? ☐ well log ☒ wetted tape ☐ probe ☐ transducer
IF WELL IS FLOWING, WHAT IS THE ARTESIAN PRESSURE HEAD AND FLOW? — m or — ft.	HOW IS PRESSURE HEAD AND FLOW MEASURED? *(specify)* —	IF SOURCE IS A FLOWING WELL OR SPRING, IS THERE A STORAGE IMPOUNDMENT OR RESERVOIR ASSOCIATED WITH THIS SOURCE? ☐ yes *(specify)* — ☐ no

WELLHEAD ELEVATION (height above mean sea level) 50 m or 164 ft.	HOW WAS ELEVATION DETERMINED? ☐ survey ☐ altimeter ☒ topographic ☐ map *(specify scale and contour interval)* ☐ other *(specify)*

TYPE OF CONFINING LAYER FROM WELL LOG (e.g., clay, till) NONE	LOCATION OF CONFINING LAYER AT DEPTH FROM WELL LOG — m or — ft.	THICKNESS OF CONFINING LAYER FROM WELL LOG — m or — ft.	HOW LATERALLY EXTENSIVE IS CONFINING LAYER? —

IS YOUR WELL ASSOCIATED WITH A KNOWN AQUIFER? ☒ yes ☐ no	NAME OF AQUIFER PUMPHANDLE AQUIFER	AQUIFER CLASSIFICATION NUMBER (from MoELP) 20	AQUIFER CLASSIFICATION (from MoELP) IIB (12)

TYPE OF AQUIFER ☒ unconsolidated, unconfined ☐ unconsolidated, confined ☐ bedrock	ARE THERE OTHER HIGH-CAPACITY WELLS, 30 L/s OR 500 GAL./MIN. (agricultural, municipal and/or industrial), LOCATED WITHIN A 300-m RADIUS OF THE COMMUNITY WELL? ☐ yes How many? NONE ☒ no	ANNUAL RAINFALL 1.52 m or 60 in.

AQUIFER TRANSMISSIVITY 310 m²/d or 25000 Igpd/ft.	HOW WAS TRANSMISSIVITY DETERMINED? ☐ from pumping test ☐ from specific capacity ☒ other *(specify)* -ASSUMED FROM PUMP TEST OF CHARLIE'S WELL
HYDRAULIC GRADIENT 0.0714	HOW WAS HYDRAULIC GRADIENT DETERMINED? ☒ from well water levels ☐ from topography ☐ other *(specify)* -BY HYDRO-LOGIC, FROM MELP'S (1983) REPORT

PLEASE IDENTIFY OR DESCRIBE ADDITIONAL HYDROLOGIC OR GEOGRAPHIC CONDITIONS THAT YOU BELIEVE MAY AFFECT TH[illegible] THE C[illegible] ZONE [illegible] SOURCE. WHERE POSSIBLE, REFERENCE THEM TO LOCATIONS ON THE MAP PRODUCED IN PART IV.

THE HILLSLOPE SOUTH OF AIKEN'S WELL SUGGESTS GROUNDWATER FLOW IS FROM THE UPHILL DIRECTION.

PART IV: ASSESSMENT OF WATER QUALITY (Refer to Step 1)

1 HOW LONG HAS THE WATER SYSTEM BEEN IN EXISTENCE? 36 YRS	2 HAS YOUR WELL EVER BEEN DEEPENED, CLEANED, NEW WELL CONSTRUCTED? ☐ yes — Why? ☒ no

3 IN THIS TIME, HAVE THERE BEEN ANY WATER QUALITY PROBLEMS? ☐ yes ☒ no ☐ don't know	IF YES, WHEN AND WHAT WAS THE CAUSE OF THESE PREVIOUS PROBLEMS (i.e., drought, pump failure, plugging, increased usage, interference, contamination)? ELEVATED NO_3-N (>3 mg/L) IN AIKEN WELL FROM LAST SAMPLING ROUND IN 1998.

IF CONTAMINATION:
- WHAT WATER QUALITY CHANGES WERE APPARENT (i.e., taste, colour, turbidity, other)?
- WHAT ACTION WAS TAKEN TO OVERCOME THIS PROBLEM?
- WHAT WERE THE EFFECTS OF THIS ACTION?

NOT ENOUGH DATA TO DETERMINE IF WATER QUALITY HAS CHANGED OVER TIME.

4 BACTERIAL CONTAMINATION

ANY BACTERIAL DETECTION(S) IN THE PAST 3 YEARS BASED ON SOURCE-MONITORING RECORDS?	☐ yes ☒ no	HAVE THERE BEEN SAMPLING PROTOCOLS OR QA/QC ESTABLISHED? ☐ yes ☒ no
HAS SOURCE (IN PAST 3 YEARS) HAD A BACTERIOLOGICAL CONTAMINATION PROBLEM FOUND IN DISTRIBUTION SAMPLES THAT WAS ATTRIBUTED TO THE SOURCE?	☐ yes ☒ no	IF YES, WHAT ARE THEY? COLLECT WATER SAMPLE FROM TAP IN OFFICE.
WAS THE BACTERIOLOGICAL CONTAMINATION DUE TO THE SOURCE?	☐ yes ☒ no	
WAS THE BACTERIOLOGICAL CONTAMINATION DUE TO CROSS-CONNECTIONS?	☐ yes ☒ no	
IS THE WELL AVAILABLE FOR DIRECT SAMPLING?	☒ yes ☐ no	

SOURCE-SPECIFIC WATER QUALITY RECORDS **(Refer to Step 1)**

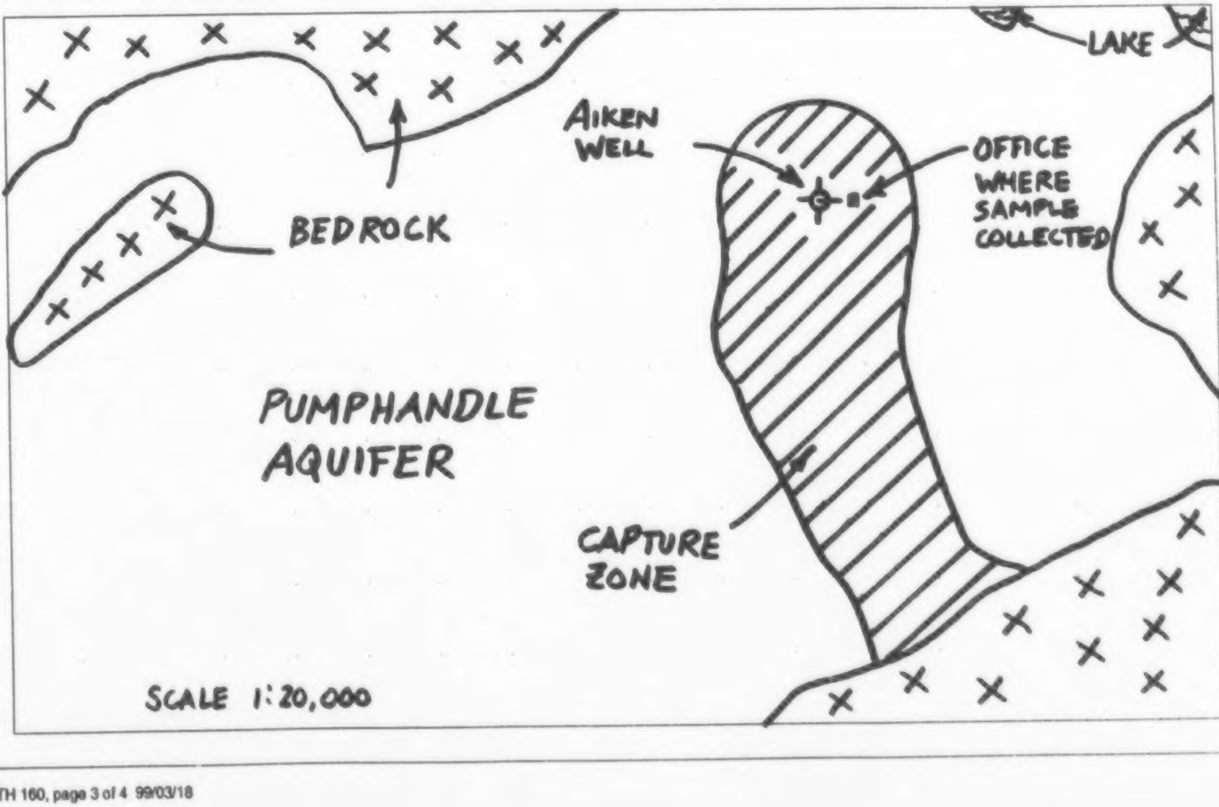
Please indicate the occurrence of any test results in the last 10 years that meet the following conditions:

PARAMETER	RECURRING PROBLEMS	TEST RESULTS	EXCEEDENCES OF CDWQG[1]
Bacteriological Total/Faecal Coliforms Background Heterotrophic plate counts Iron and Sulphate Reducers	NONE		NEVER DETECTED
Disinfection by-products Bromodichloromethane Dibromochloromethane Chloroform	NONE, WELL WATER NOT CHLORINATED		NEVER DETECTED
Physical Parameters pH, colour, alkalinity, specific conductance, hardness, total dissolved solids, total organic carbon, turbidity	NONE		
Inorganic Parameters Nitrates, fluoride, sulfate, sulphide, ammonia, chloride, nitrite, nitrogen (organic)	ELEVATED NO_3-N IN 4 OF 4 SAMPLING ROUNDS	6.2-8 mg/L	NO EXCEEDENCES
Metals* Calcium, iron, magnesium, manganese, sodium	NONE		NO EXCEEDENCES

[1] Canadian Drinking Water Quality Guidelines, 6th edition

* A metal scan is usually performed every 3 years at least, and includes aluminum, arsenic, barium, cadmium, chromium, copper, lead, molybdenum, nickel, phosphorus, silver and zinc.

Please sketch in the box below the location sampling point with respect to the well.



PART V: WATER TREATMENT INFORMATION (Refer to Step 1)

IS THIS SOURCE TREATED? ☐ yes ☒ no

IF YES, TYPE OF TREATMENT ☐ disinfection ☐ filtration ☐ carbon filter ☐ air stripper ☐ water softener ☐ other (specify) N/A

PURPOSE OF TREATMENT N/A, SOURCE NOT TREATED

IF SOURCE IS CHLORINATED, IS A CHLORINE RESIDUAL MAINTAINED?	Total Chlorine — ppm	Free Chlorine — ppm	WHAT IS THE RESIDUAL LEVEL OF TREATMENT? —
IS THERE ANY WATER STORAGE IN THE SYSTEM? ☒ yes ☐ no			IS THE WATER TREATMENT BEFORE OR AFTER THE STORAGE UNIT? ☐ before ☐ after
WHAT IS THE TOTAL AND FREE CHLORINE IN THE DISTRIBUTION SYSTEM?	Total Chlorine — ppm	Free Chlorine — ppm	IS THERE ANY ADDITIONAL CHLORINE ADDED AFTER THE SOURCE (rechlorination)? Total Chlorine — ppm Free Chlorine — ppm
WHAT TYPE OF CHEMICALS ARE USED IN THIS PROCESS? (specify) —			WHERE ARE CHEMICALS STORED? —
IS THERE PROPER STORAGE FOR THESE CHEMICALS? ☒ yes ☐ no			IF STORED IN PUMP HOUSE, HOW ARE CHEMICALS ISOLATED FROM THE WELL? —

PART VI: MAPPING THE CAPTURE ZONE TO YOUR COMMUNITY WELL (Refer to Step 2)

A map (1:5000 to 1:20,000 are typical scales) will be needed to complete this section. Multiple wells in the same area can be plotted on one map.

CIRCULAR CAPTURE ZONE (refer to Appendix 2.1)

	*attach calculation sheets	RADIUS (m)
	Arbitrary Fixed Radius	300
Calculated Fixed Radius	(1-year travel time)*	99
	(5-year travel time)*	221
	(10-year travel time)*	312

PARABOLIC CAPTURE ZONE (refer to Appendix 2.2)*

Downgradient distance 2 m

Width of capture zone 16 m

Is there a river, lake, pond, stream or other obvious surface water body within the 6-month time of travel boundary? ☐ yes *(identify on map)* ☒ no

Is there a stormwater and/or wastewater facility, treatment lagoon or holding pond located within the 6-month time of travel boundary? ☐ yes *(identify on map)* ☒ no

PART VII: SOURCE SURVEY (Refer to Step 3)

4 REGIONAL SOURCES OF RISK TO GROUND WATER

Please indicate if any of the following potential sources of contamination within the capture zone.

ACTIVITY	T.O.T. NOT SPECIFIED	1-YEAR	5-YEAR	10-YEAR	COMMENTS
Chemical Storage *(specify)*	✓				
Injection wells					
Abandoned wells					
Landfills, dumps, disposal areas					
Commercial/industrial sites	✓				GAS STATION; DRY CLEANER
Known hazardous materials clean-up site					
Household hazardous waste					
Population density > 2 houses per hectare	✓				
On-site sewage treatment	✓				
Wastewater treatment facility					
Sites used for land application of waste					
Golf course					
Dairy or beef farms					
Poultry barns					
Hobby farms					
Fields: vegetables, hay, fruit *(specify)*	✓				
Mining operations					
Gravel pits	✓				

** Mark and identify on map any of the potential sources listed above which are located within the capture zone boundary.

SEPTIC FIELD SETBACK	GRADIENT TO SEPTIC FIELD	DENSITY OF ON-SITE SEWAGE DISPOSAL SYSTEMS: COMMUNITY SYSTEM	SYSTEM PER LOT
90 m or 300 ft.	☐ upgrade ☒ downgrade ☐ same grade ___ % 0.4 %	NONE	1 PER LOT (23/ha)

BRITISH COLUMBIA
Ministry of Health and Ministry Responsible for Seniors
Ministry of Environment, Lands and Parks

WELL ASSESSMENT FORM

TO BE USED WITH THE WELL PROTECTION TOOLKIT.

IMPORTANT! Please complete one form for each ground water source used in your water system. Fill in available information. If missing information, it may be advisable to contact the Ministry of Environment, Lands and Parks' Groundwater Section [(250) 387-1115], or the local driller who drilled the well, to assist. Photocopy this form as necessary.

PART I: WELL SYSTEM INFORMATION (Refer to Step 1)

WATER SYSTEM LEGAL NAME: BLACKWATER WATERWORKS LTD.

LEGAL DESCRIPTION OF WELL LOCATION: SEC. 10, TP22, PL54872 NEW WEST

WATER SYSTEM LEGAL ADDRESS: 1900 PUMPHANDLE HWY. PUMPHANDLE, BC

LATITUDE / LONGITUDE: —

HOW WERE LOCATION COORDINATES DETERMINED? ☐ GPS ________ *(specify accuracy)* ☐ survey ☐ digitized from ________ map *(specify scale)*

UTM COORDINATES: E:571940; N:5431980

HOW MANY OTHER WELLS MAKE UP THE WATER SYSTEM? 1

DOES THE WATER SYSTEM ALSO USE A SURFACE WATER SOURCE? *(describe)* NO

NUMBER OF CONNECTIONS: Maximum ________ Actual 35

POPULATION SERVED: 100

WATER USE: ☒ domestic ☒ irrigation ☐ commercial ☐ industrial other *(specify)* ________

WIN NO.: 45214

EMS NO.: E219651

WELL TAG NO.: —

Contact your local Ministry of Environment, Lands and Parks office or local Health Unit for the following information:

WIN NO. = MoELP's metal tag affixed to the well for on-site identification.

EMS NO. = MoELP's site number for the water chemistry on their database.

BC WELL TAG NO. = MoELP's computer number for the well.

Bulk supply ☒ yes ☐ no

Back-up supply ☐ yes ☒ no

Emergency supply ☐ yes ☒ no

Metered ☒ yes ☐ no

WELL OWNER / OPERATOR INFORMATION

WELL OPERATOR: JENNY LOWDEN

WELL OPERATOR'S PHONE NO.: (604) 853-4868

WELL OPERATOR'S ADDRESS: 1900 PUMPHANDLE HWY, PUMPHANDLE, BC

WELL OWNER: JENNY LOWDEN

WELL OWNER'S PHONE NO.: ( ) AS ABOVE

WELL OWNER'S ADDRESS: AS ABOVE

PART II: WELL CONSTRUCTION INFORMATION (Refer to Step 1)

WELL-DRILLER'S NAME, COMPANY AND ADDRESS:
A-1 DRILLING
PO BOX 83
ABBOTSFORD, BC V2S 4N7

POSTAL CODE: V2S 4N7

WELL-DRILLER'S TELEPHONE NO.: (604) 853-5231

DATE WELL ORIGINALLY CONSTRUCTED (YYYY MM DD): 1980 06 17

DATE OF LAST RECONSTRUCTION (YYYY MM DD): 1980 06 17

TYPE OF WELL: ☒ drilled ☐ dug ☐ other *(specify)* ________

METHOD OF DRILLING: ☒ rotary ☐ cable tool ☐ driven ☐ jetted ☐ other *(specify)* ________

WELL LOG AVAILABLE? ☒ yes *(attach)* ☐ no

DEPTH OF WELL: 30.5 m or 100 ft.

DIAMETER OF WELL: 0.20 m or 8 in.

SCREEN LENGTH: 1.52 m or 5 ft.

DEPTH TO TOP OF SCREEN: 28.96 m or 95 ft.

WELL CAPACITY: 22.7 L/s or 300 Igpm

LOCATION OF WATER-BEARING FRACTION(S) (for bedrock wells): —

YIELD OF WATER-BEARING FRACTION(S): — L/s or — Igpm

WELLHEAD ENCLOSURE: ☒ pump house ☐ manhole ☐ other *(specify)* ________ ☐ none

SURFACE SANITARY SEAL: grouted to — m or — ft. ☒ no surface seal ☐ pitless adapter

AVERAGE PUMPING RATE: 4.7 L/s or 62 Igpm

HOW WAS PUMPING RATE DETERMINED? AVERAGED FROM ANNUAL VOLUME

DEPTH OF INTAKE SETTING: 27.4 m or 90 ft

PUMP AGE: 19 YRS

ANNUAL VOLUME OF WATER PUMPED: 148,516,000 32670000

HOW WAS VOLUME PUMPED DETERMINED? METERING RECORDS FROM LAST YEAR

PUMPING CAPACITY: 25 L/s or 330 Igpm

ANY CHANGES OR REPAIRS MADE TO THE PUMPING EQUIPMENT? *(specify)* REGULAR MAINTENANCE

TYPE OF STORAGE: ☒ tank(s) ☐ reservoir ☐ other *(specify)* ________

STORAGE CAPACITY: 113650 L or 25000 Igal

COMMON INLET OR OUTLET? ☐ yes ☒ no

ATTACHED INFORMATION: ☒ well log ☐ drawings ☐ reports ☐ pump test data ☐ water quality data

NOTE: If no well log is available, please attach any other records documenting well construction (i.e., "as built" drawings, engineering reports).

PART III: HYDROGEOLOGIC INFORMATION (Refer to Steps 1 and 2)

DEPTH TO PUMPING WATER LEVEL 13.77 m or 45.2 ft.	DEPTH TO NON-PUMPING WATER LEVEL 12.2 m or 40 ft.	HOW WAS WATER LEVEL MEASURED? ☒ well log ☐ wetted tape ☐ probe ☐ transducer
IF WELL IS FLOWING, WHAT IS THE ARTESIAN PRESSURE HEAD AND FLOW? — m or — ft.	HOW IS PRESSURE HEAD AND FLOW MEASURED? *(specify)* —	IF SOURCE IS A FLOWING WELL OR SPRING, IS THERE A STORAGE IMPOUNDMENT OR RESERVOIR ASSOCIATED WITH THIS SOURCE? ☐ yes *(specify)* — ☐ no

WELLHEAD ELEVATION (height above mean sea level) 50 m or 164 ft.	HOW WAS ELEVATION DETERMINED? ☐ survey ☐ altimeter ☒ topographic ☐ map *(specify scale and contour interval)* ☐ other *(specify)*

TYPE OF CONFINING LAYER FROM WELL LOG (e.g., clay, till) CLAY	LOCATION OF CONFINING LAYER AT DEPTH FROM WELL LOG 26.2-27.7 m or 86-91 ft.	THICKNESS OF CONFINING LAYER FROM WELL LOG 1.5 m or 5 ft.	HOW LATERALLY EXTENSIVE IS CONFINING LAYER? UNKNOWN
IS YOUR WELL ASSOCIATED WITH A KNOWN AQUIFER? ☒ yes ☐ no	NAME OF AQUIFER PUMPHANDLE AQUIFER	AQUIFER CLASSIFICATION NUMBER (from MoELP) 20	AQUIFER CLASSIFICATION (from MoELP) IIB(12)

TYPE OF AQUIFER ☒ unconsolidated, unconfined ☐ unconsolidated, confined ☐ bedrock	ARE THERE OTHER HIGH-CAPACITY WELLS, 30 L/s OR 500 GAL./MIN. (agricultural, municipal and/or industrial), LOCATED WITHIN A 300-m RADIUS OF THE COMMUNITY WELL? ☐ yes How many? NONE ☒ no	ANNUAL RAINFALL 1.52 m or 60 in.

AQUIFER TRANSMISSIVITY 310 m²/d or 25000 Igpd/ft.	HOW WAS TRANSMISSIVITY DETERMINED? ☐ from pumping test ☒ from specific capacity ☒ other *(specify)* ALSO ASSUMED FROM PUMPING TEST OF CHARLIE'S WELL
HYDRAULIC GRADIENT 0.0050	HOW WAS HYDRAULIC GRADIENT DETERMINED? ☒ from well water levels ☐ from topography ☐ other *(specify)* FROM MELP'S (1983) REPORT

PLEASE IDENTIFY OR DESCRIBE ADDITIONAL HYDROLOGIC OR GEOGRAPHIC CONDITIONS THAT YOU BELIEVE MAY AFFECT THE SHAPE OF THE CAPTURE ZONE FOR THIS SOURCE. WHERE POSSIBLE, REFERENCE THEM TO LOCATIONS ON THE MAP PRODUCED IN PART IV.

THE IMPACT OF PUMPHANDLE CK. NEARBY IS NOT CLEAR.

PART IV: ASSESSMENT OF WATER QUALITY (Refer to Step 1)

1 HOW LONG HAS THE WATER SYSTEM BEEN IN EXISTENCE? 17 YRS	2 HAS YOUR WELL EVER BEEN DEEPENED, CLEANED, NEW WELL CONSTRUCTED? ☐ yes — Why? ☒ no
3 IN THIS TIME, HAVE THERE BEEN ANY WATER QUALITY PROBLEMS? ☐ yes ☒ no ☐ don't know	IF YES, WHEN AND WHAT WAS THE CAUSE OF THESE PREVIOUS PROBLEMS (i.e., drought, pump failure, plugging, increased usage, interference, contamination)? ELEVATED NO_3-N (>3mg/L) IN LAST SAMPLING ROUND IS OF CONCERN

IF CONTAMINATION:
- WHAT WATER QUALITY CHANGES WERE APPARENT (i.e., taste, colour, turbidity, other)?
- WHAT ACTION WAS TAKEN TO OVERCOME THIS PROBLEM?
- WHAT WERE THE EFFECTS OF THIS ACTION?

NOT ENOUGH DATA TO DETERMINE IF WATER QUALITY HAS CHANGED OVER TIME.

4 BACTERIAL CONTAMINATION

ANY BACTERIAL DETECTION(S) IN THE PAST 3 YEARS BASED ON SOURCE-MONITORING RECORDS?		☐ yes ☒ no
HAS SOURCE (IN PAST 3 YEARS) HAD A BACTERIOLOGICAL CONTAMINATION PROBLEM FOUND IN DISTRIBUTION SAMPLES THAT WAS ATTRIBUTED TO THE SOURCE?		☐ yes ☒ no
WAS THE BACTERIOLOGICAL CONTAMINATION DUE TO THE SOURCE?	N/A	☐ yes ☐ no
WAS THE BACTERIOLOGICAL CONTAMINATION DUE TO CROSS-CONNECTIONS?	N/A	☐ yes ☐ no
IS THE WELL AVAILABLE FOR DIRECT SAMPLING?		☒ yes ☐ no

HAVE THERE BEEN SAMPLING PROTOCOLS OR QA/QC ESTABLISHED? ☐ yes ☒ no

IF YES, WHAT ARE THEY?

COLLECT SAMPLE FROM TAP IN WATERWORKS OFFICE & DROP SAMPLE OFF AT HEALTH UNIT; NO QA/QC SAMPLES.

SOURCE-SPECIFIC WATER QUALITY RECORDS **(Refer to Step 1)**

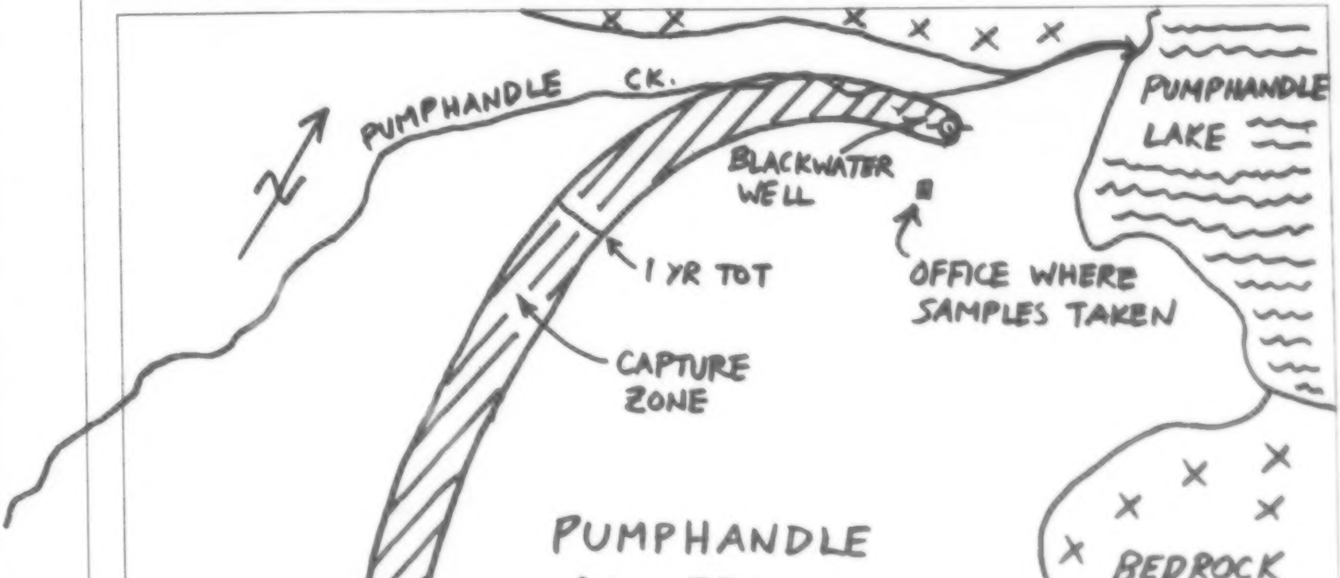
Please indicate the occurrence of any test results in the last 10 years that meet the following conditions:

PARAMETER	RECURRING PROBLEMS	TEST RESULTS	EXCEEDENCES OF CDWQG[1]
Bacteriological Total/Faecal Coliforms Background Heterotrophic plate counts Iron and Sulphate Reducers	NONE		NEVER DETECTED
Disinfection by-products Bromodichloromethane Dibromochloromethane Chloroform	NONE; WELL WATER IS NOT CHLORINATED	ALWAYS AT "ND"	NEVER DETECTED
Physical Parameters pH, colour, alkalinity, specific conductance, hardness, total dissolved solids, total organic carbon, turbidity	NONE		NO EXCEEDENCES
Inorganic Parameters Nitrates, fluoride, sulfate, sulphide, ammonia, chloride, nitrite, nitrogen (organic)	ELEVATED NO_3-N IN 3 OF 4 SAMPLING ROUNDS	2.0 - 5.6 mg/L	NO EXCEEDENCES
Metals* Calcium, iron, magnesium, manganese, sodium	ELEVATED Mn	0.03 - 0.04 mg/L Mn	NO EXCEEDENCES

[1] Canadian Drinking Water Quality Guidelines, 6th edition

* A metal scan is usually performed every 3 years at least, and includes aluminum, arsenic, barium, cadmium, chromium, copper, lead, molybdenum, nickel, phosphorus, silver and zinc.

Please sketch in the box below the location sampling point with respect to the well.



PART V: WATER TREATMENT INFORMATION (Refer to Step 1)

IS THIS SOURCE TREATED? ☐ yes ☒ no

IF YES, TYPE OF TREATMENT ☐ disinfection ☐ filtration ☐ carbon filter ☐ air stripper ☐ water softener ☐ other (*specify*) —

PURPOSE OF TREATMENT: SOURCE NOT TREATED

IF SOURCE IS CHLORINATED, IS A CHLORINE RESIDUAL MAINTAINED? Total Chlorine — ppm Free Chlorine — ppm

WHAT IS THE RESIDUAL LEVEL OF TREATMENT? —

IS THERE ANY WATER STORAGE IN THE SYSTEM? ☒ yes ☐ no

IS THE WATER TREATMENT BEFORE OR AFTER THE STORAGE UNIT? N/A ☐ before ☐ after

WHAT IS THE TOTAL AND FREE CHLORINE IN THE DISTRIBUTION SYSTEM? Total Chlorine — ppm Free Chlorine — ppm

IS THERE ANY ADDITIONAL CHLORINE ADDED AFTER THE SOURCE (rechlorination)? Total Chlorine — ppm Free Chlorine — ppm

WHAT TYPE OF CHEMICALS ARE USED IN THIS PROCESS? (*specify*) —

WHERE ARE CHEMICALS STORED? A COUPLE OF LITRES OF OIL

IS THERE PROPER STORAGE FOR THESE CHEMICALS? ☐ yes ☒ no

IF STORED IN PUMP HOUSE, HOW ARE CHEMICALS ISOLATED FROM THE WELL? OIL STORED IN TOOL CABINET

PART VI: MAPPING THE CAPTURE ZONE TO YOUR COMMUNITY WELL (Refer to Step 2)

A map (1:5000 to 1:20,000 are typical scales) will be needed to complete this section. Multiple wells in the same area can be plotted on one map.

CIRCULAR CAPTURE ZONE (refer to Appendix 2.1)

	*attach calculation sheets	RADIUS (m)
Arbitrary Fixed Radius		300
Calculated Fixed Radius	(1-year travel time)*	232
	(5-year travel time)*	518
	(10-year travel time)*	733

PARABOLIC CAPTURE ZONE (refer to Appendix 2.2)*

Downgradient distance 27 m

Width of capture zone 172 m

Is there a river, lake, pond, stream or other obvious surface water body within the 6-month time of travel boundary? ☒ yes (*identify on map*) ☐ no

Is there a stormwater and/or wastewater facility, treatment lagoon or holding pond located within the 6-month time of travel boundary? ☐ yes (*identify on map*) ☒ no

PART VII: SOURCE SURVEY (Refer to Step 3)

4 REGIONAL SOURCES OF RISK TO GROUND WATER

Please indicate if any of the following potential sources of contamination within the capture zone.

ACTIVITY	T.O.T. NOT SPECIFIED	1-YEAR	5-YEAR	10-YEAR	COMMENTS
Chemical Storage (*specify*)		✓	✓		GOLF COURSE; CORN FIELD; MOTOR OIL IN PUMPHOUSE
Injection wells					
Abandoned wells			✓		
Landfills, dumps, disposal areas					
Commercial/industrial sites					
Known hazardous materials clean-up site					
Household hazardous waste					
Population density > 2 houses per hectare					
On-site sewage treatment					
Wastewater treatment facility					
Sites used for land application of waste					
Golf course					
Dairy or beef farms					
Poultry barns			✓		
Hobby farms					
Fields: vegetables, hay, fruit (*specify*)			✓		CORN FIELD
Mining operations					
Gravel pits					

** Mark and identify on map any of the potential sources listed above which are located within the capture zone boundary.

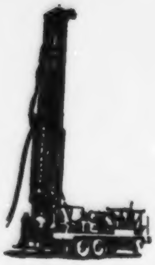
SEPTIC FIELD SETBACK >200 m or >650 ft.

GRADIENT TO SEPTIC FIELD ☐ upgrade ☐ downgrade ☒ same grade ____ % ____ %

DENSITY OF ON-SITE SEWAGE DISPOSAL SYSTEMS

COMMUNITY SYSTEM: 1 FOR GOLF COURSE

SYSTEM PER LOT: 1 PER 2-3 Ha BUT NE OF CAPTURE ZONE



TELEPHONE:
(604) 853-[redacted]

A-1 DRILLING

"Specializing in Water Wells, Soil Sampling, Exploration"

ABBOTSFORD, B.C.
V2S 4N7

INVOICE No. 725

TO .... BLACK WATER Golf Course.

ADDRESS 1900 PUMPHANDLE HIGHWAY, POMPHANDLE, BC

WELL DRILLED AT .... Same

WELL COMPLETED .... June 17/80 .... INVOICE DATE .... June 19, 1980

	Machine Hours at .... per Hour	
	Feet of Drilling at .... per Foot	
100	Feet of Drilling & Casing at $25.00 per Foot	2,500.00
	Feet of ...... Casing at .... per Foot	
	Feet of ...... Casing at .... per Foot	
	Feet of ...... Casing at .... per Foot	
1. 8"	Drive Shoes at .... each	110.00
5	Feet of 120 slot Screen	575.00
Installation of Screen		
Pump Testing	Hours at .... per Hour	
Surging and Baling	Hours at .... per Hour	
Other Charges:		
	Moving on Site and Setting Up	
	Blasting	
	Other 2 hrs developing well @ 60.00	120.00
	Room and Board	
	Travelling and Tolls	
TOTAL INVOICE PRICE		$3,305.00

Notations Set screen from 95' to 100'.
Pumped well at approximately 300 G.P.M.
Static water level at 40 ft.

LOG OF WELL

	Sand & Gravel
86'	Clay
[illegible]	Sand & Gravel
100'	

INVOIC

Account due on presentation of this invoice.
Interest at 1½% per Month (18% per Annum) on all accounts overdue 30 days.

BRITISH COLUMBIA
Ministry of Health and Ministry Responsible for Seniors
Ministry of Environment, Lands and Parks

WELL ASSESSMENT FORM

TO BE USED WITH THE WELL PROTECTION TOOLKIT.

IMPORTANT! Please complete one form for each ground water source used in your water system. Fill in available information. If missing information, it may be advisable to contact the Ministry of Environment, Lands and Parks' Groundwater Section [(250) 387-1 115], or the local driller who drilled the well, to assist. Photocopy this form as necessary.

PART I: WELL SYSTEM INFORMATION (Refer to Step 1)

WATER SYSTEM LEGAL NAME: CHARLIE'S IMPROVEMENT DISTRICT

LEGAL DESCRIPTION OF WELL LOCATION: LOT REM E, PL 23151, TP 22, NEW WEST

WATER SYSTEM LEGAL ADDRESS: 1735 SPRING CREEK DRIVE, PUMPHANDLE, BC

LATITUDE / LONGITUDE: —

HOW WERE LOCATION COORDINATES DETERMINED? ☐ GPS ______ *(specify accuracy)* ☐ survey ☐ digitized from ______ map *(specify scale)*

UTM COORDINATES: E:572270; N:5431760

HOW MANY OTHER WELLS MAKE UP THE WATER SYSTEM? 1

DOES THE WATER SYSTEM ALSO USE A SURFACE WATER SOURCE? *(describe)* NO

NUMBER OF CONNECTIONS: Maximum 15 Actual 15

POPULATION SERVED: 50

WATER USE: ☒ domestic ☐ irrigation ☐ commercial ☐ industrial other *(specify)* ______

WIN NO.: 53593

EMS NO.: E 218104

WELL TAG NO.: —

Contact your local Ministry of Environment, Lands and Parks office or local Health Unit for the following information:

WIN NO. = MoELP's metal tag affixed to the well for on-site identification.

EMS NO. = MoELP's site number for the water chemistry on their database.

BC WELL TAG NO. = MoELP's computer number for the well.

Bulk supply ☒ yes ☐ no | Back-up supply ☐ yes ☒ no | Emergency supply ☐ yes ☒ no | Metered ☒ yes ☐ no

WELL OWNER / OPERATOR INFORMATION

WELL OPERATOR: ERIC KOWSKI

WELL OPERATOR'S PHONE NO.: (604) 853-8160

WELL OPERATOR'S ADDRESS: 1735 SPRING CREEK DRIVE, PUMPHANDLE, BC

WELL OWNER: ERIC KOWSKI

WELL OWNER'S PHONE NO.: ( ) AS ABOVE

WELL OWNER'S ADDRESS: AS ABOVE

PART II: WELL CONSTRUCTION INFORMATION (Refer to Step 1)

WELL-DRILLER'S NAME, COMPANY AND ADDRESS:

A1 DRILLING
PO BOX 83
ABBOTSFORD, BC V2S 4N7

POSTAL CODE: V2S 4N7

WELL-DRILLER'S TELEPHONE NO.: (604) 853-5231

DATE WELL ORIGINALLY CONSTRUCTED (YYYY MM DD): 1984 05 24

DATE OF LAST RECONSTRUCTION (YYYY MM DD): 1984 05 24

TYPE OF WELL: ☒ drilled ☐ dug ☐ other *(specify)* ______

METHOD OF DRILLING: ☒ rotary ☐ cable tool ☐ driven ☐ jetted ☐ other *(specify)* ______

WELL LOG AVAILABLE? ☒ yes (attach) ☐ no

DEPTH OF WELL: 25.6 m or 84 ft.

DIAMETER OF WELL: 0.15 m or 6 in.

SCREEN LENGTH: 1.22 m or 4 ft.

DEPTH TO TOP OF SCREEN: 24.38 m or 80 ft.

WELL CAPACITY: 7.58 L/s or 100 Igpm

LOCATION OF WATER-BEARING FRACTION(S) (for bedrock wells): —

YIELD OF WATER-BEARING FRACTION(S): — L/s or — Igpm

WELLHEAD ENCLOSURE: ☒ pump house ☐ manhole ☐ other *(specify)* ______ ☐ none

SURFACE SANITARY SEAL: grouted to — m or — ft. ☒ no surface seal ☐ pitless adapter

AVERAGE PUMPING RATE: 0.53 L/s or 7 Igpm

HOW WAS PUMPING RATE DETERMINED? AVERAGED FROM ANNUAL VOLUME

DEPTH OF INTAKE SETTING: 23.8 m or 78 ft.

PUMP AGE: 14YRS

ANNUAL VOLUME OF WATER PUMPED: 16714080 or 3679200 Igal

HOW WAS VOLUME PUMPED DETERMINED? METERING RECORDS FROM 1993-1998

PUMPING CAPACITY: 1.5 L/s or 20 Igpm

ANY CHANGES OR REPAIRS MADE TO THE PUMPING EQUIPMENT? *(specify)* REGULAR MAINTENANCE

TYPE OF STORAGE: ☒ tank(s) ☐ reservoir ☐ other *(specify)* ______

STORAGE CAPACITY: 45500 L or 10 000 Igal

COMMON INLET OR OUTLET? ☐ yes ☒ no

ATTACHED INFORMATION: ☒ well log ☐ drawings ☐ reports ☐ pump test data ☐ water quality data

NOTE: If no well log is available, please attach any other records documenting well construction (i.e., "as built" drawings, engineering reports).

PART III: HYDROGEOLOGIC INFORMATION (Refer to Steps 1 and 2)

DEPTH TO PUMPING WATER LEVEL 1.36 m or 4.4 ft.

DEPTH TO NON-PUMPING WATER LEVEL -0.31 m or -1 ft.

HOW WAS WATER LEVEL MEASURED? ☐ well log ☒ wetted tape ☐ probe ☐ transducer

IF WELL IS FLOWING, WHAT IS THE ARTESIAN PRESSURE HEAD AND FLOW? 0.31 m or 1 ft.

HOW IS PRESSURE HEAD AND FLOW MEASURED? *(specify)* WETTED TAPE (STICKUP IS 3')

IF SOURCE IS A FLOWING WELL OR SPRING, IS THERE A STORAGE IMPOUNDMENT OR RESERVOIR ASSOCIATED WITH THIS SOURCE? ☒ yes *(specify)* STORAGE TANK ☐ no

WELLHEAD ELEVATION (height above mean sea level) 48.5 m or 159 ft.

HOW WAS ELEVATION DETERMINED? ☐ survey ☐ altimeter ☒ topographic ☐ map *(specify scale and contour interval)* ☐ other *(specify)*

TYPE OF CONFINING LAYER FROM WELL LOG (e.g., clay, till) CLAY

LOCATION OF CONFINING LAYER AT DEPTH FROM WELL LOG 17.7-19.5 58-64 ft.

THICKNESS OF CONFINING LAYER FROM WELL LOG 1.8 m or 6 ft.

HOW LATERALLY EXTENSIVE IS CONFINING LAYER? UNKNOWN

IS YOUR WELL ASSOCIATED WITH A KNOWN AQUIFER? ☒ yes ☐ no

NAME OF AQUIFER PUMPHANDLE AQUIFER

AQUIFER CLASSIFICATION NUMBER (from MoELP) 20

AQUIFER CLASSIFICATION (from MoELP) IIB (12)

TYPE OF AQUIFER ☒ unconsolidated, unconfined ☐ unconsolidated, confined ☐ bedrock

ARE THERE OTHER HIGH-CAPACITY WELLS, 30 L/s OR 500 GAL./MIN. (agricultural, municipal and/or industrial), LOCATED WITHIN A 300-m RADIUS OF THE COMMUNITY WELL? ☐ yes How many? NONE ☒ no

ANNUAL RAINFALL 1.52 m or 60 in.

AQUIFER TRANSMISSIVITY 310 m²/d or 25000 Igpd/ft.

HOW WAS TRANSMISSIVITY DETERMINED? ☒ from pumping test ☐ from specific capacity ☐ other *(specify)*

HYDRAULIC GRADIENT 0.0033

HOW WAS HYDRAULIC GRADIENT DETERMINED? ☒ from well water levels ☐ from topography ☐ other *(specify)* FROM MELP'S (1983) REPORT

PLEASE IDENTIFY OR DESCRIBE ADDITIONAL HYDROLOGIC OR GEOGRAPHIC CONDITIONS THAT YOU BELIEVE MAY AFFECT THE SHAPE OF THE CAPTURE ZONE FOR THIS SOURCE. WHERE POSSIBLE, REFERENCE THEM TO LOCATIONS ON THE MAP PRODUCED IN PART IV.

THE PRESENCE OF THE UNAMED SPRING CREEK & ITS IMPACT ON THE CAPTURE ZONE IS NOT CLEAR.

THE IMPACT OF TWO IRRIGATION WELLS DIRECTLY SE OF CHARLIE'S WELL IS NOT KNOWN.

PART IV: ASSESSMENT OF WATER QUALITY (Refer to Step 1)

1 HOW LONG HAS THE WATER SYSTEM BEEN IN EXISTENCE? 14 YRS

2 HAS YOUR WELL EVER BEEN DEEPENED, CLEANED, NEW WELL CONSTRUCTED? ☐ yes — Why? ☒ no

3 IN THIS TIME, HAVE THERE BEEN ANY WATER QUALITY PROBLEMS? ☐ yes ☒ no ☐ don't know

IF YES, WHEN AND WHAT WAS THE CAUSE OF THESE PREVIOUS PROBLEMS (i.e., drought, pump failure, plugging, increased usage, interference, contamination)? ELEVATED NO_3-N (>3 mg/L) FROM LAST SAMPLING ROUND IN 1998.

IF CONTAMINATION: • WHAT WATER QUALITY CHANGES WERE APPARENT (i.e., taste, colour, turbidity, other)? • WHAT ACTION WAS TAKEN TO OVERCOME THIS PROBLEM? • WHAT WERE THE EFFECTS OF THIS ACTION?

NOT ENOUGH DATA TO DETERMINE IF WATER QUALITY HAS CHANGED OVER TIME; PRESENCE OF NO_3-N IN THE WELL WATER IS A CONCERN, HOWEVER

4 BACTERIAL CONTAMINATION

ANY BACTERIAL DETECTION(S) IN THE PAST 3 YEARS BASED ON SOURCE-MONITORING RECORDS? ☐ yes ☒ no

HAS SOURCE (IN PAST 3 YEARS) HAD A BACTERIOLOGICAL CONTAMINATION PROBLEM FOUND IN DISTRIBUTION SAMPLES THAT WAS ATTRIBUTED TO THE SOURCE? ☐ yes ☒ no

WAS THE BACTERIOLOGICAL CONTAMINATION DUE TO THE SOURCE? N/A ☐ yes ☐ no

WAS THE BACTERIOLOGICAL CONTAMINATION DUE TO CROSS-CONNECTIONS? N/A ☐ yes ☐ no

IS THE WELL AVAILABLE FOR DIRECT SAMPLING? ☒ yes ☐ no

HAVE THERE BEEN SAMPLING PROTOCOLS OR QA/QC ESTABLISHED? ☐ yes ☒ no

IF YES, WHAT ARE THEY? COLLECT SAMPLE FROM PUMPHOUSE

SOURCE-SPECIFIC WATER QUALITY RECORDS **(Refer to Step 1)**

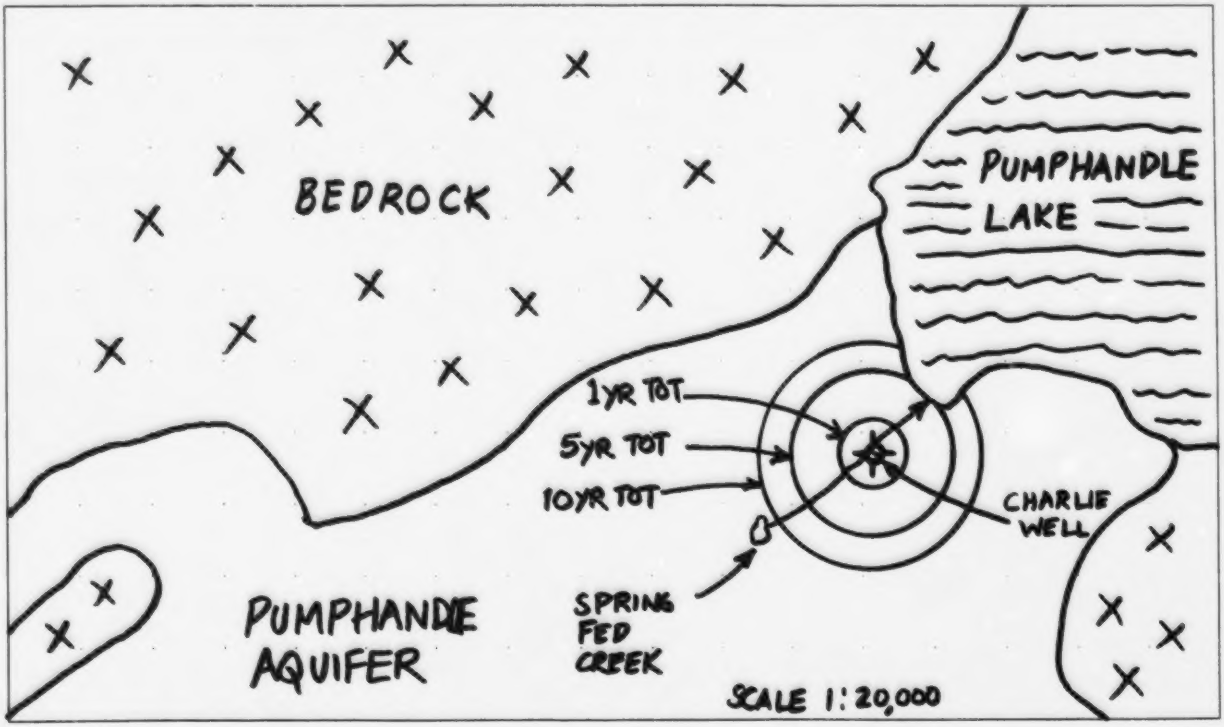
Please indicate the occurrence of any test results in the last 10 years that meet the following conditions:

PARAMETER	RECURRING PROBLEMS	TEST RESULTS	EXCEEDENCES OF CDWQG[1]
Bacteriological Total/Faecal Coliforms Background Heterotrophic plate counts Iron and Sulphate Reducers	NONE		NEVER DETECTED
Disinfection by-products Bromodichloromethane Dibromochloromethane Chloroform	NONE; WELL WATER NOT CHLORINATED		NEVER DETECTED
Physical Parameters pH, colour, alkalinity, specific conductance, hardness, total dissolved solids, total organic carbon, turbidity	NONE		
Inorganic Parameters Nitrates, fluoride, sulfate, sulphide, ammonia, chloride, nitrite, nitrogen (organic)	ELEVATED NO_3-N IN 2 OF 4 SAMPLING ROUNDS	1.6 - 4 mg/L	NO EXCEEDENCES
Metals* Calcium, iron, magnesium, manganese, sodium	ELEVATED Mn	0.01-0.03 mg/L	NO EXCEEDENCES

[1] Canadian Drinking Water Quality Guidelines, 6th edition

* A metal scan is usually performed every 3 years at least, and includes aluminum, arsenic, barium, cadmium, chromium, copper, lead, molybdenum, nickel, phosphorus, silver and zinc.

Please sketch in the box below the location sampling point with respect to the well.



PART V: WATER TREATMENT INFORMATION (Refer to Step 1)

IS THIS SOURCE TREATED? ☐ yes ☒ no

IF YES, TYPE OF TREATMENT ☐ disinfection ☐ filtration ☐ carbon filter ☐ air stripper ☐ water softener ☐ other *(specify)* N/A

PURPOSE OF TREATMENT —

IF SOURCE IS CHLORINATED, IS A CHLORINE RESIDUAL MAINTAINED? Total Chlorine — ppm Free Chlorine — ppm

WHAT IS THE RESIDUAL LEVEL OF TREATMENT? —

IS THERE ANY WATER STORAGE IN THE SYSTEM? ☒ yes ☐ no

IS THE WATER TREATMENT BEFORE OR AFTER THE STORAGE UNIT? N/A ☐ before ☐ after

WHAT IS THE TOTAL AND FREE CHLORINE IN THE DISTRIBUTION SYSTEM? Total Chlorine — ppm Free Chlorine — ppm

IS THERE ANY ADDITIONAL CHLORINE ADDED AFTER THE SOURCE (rechlorination)? Total Chlorine — ppm Free Chlorine — ppm

WHAT TYPE OF CHEMICALS ARE USED IN THIS PROCESS? *(specify)* —

WHERE ARE CHEMICALS STORED? —

IS THERE PROPER STORAGE FOR THESE CHEMICALS? ☒ yes ☐ no

IF STORED IN PUMP HOUSE, HOW ARE CHEMICALS ISOLATED FROM THE WELL? —

PART VI: MAPPING THE CAPTURE ZONE TO YOUR COMMUNITY WELL (Refer to Step 2)

A map (1:5000 to 1:20,000 are typical scales) will be needed to complete this section. Multiple wells in the same area can be plotted on one map.

CIRCULAR CAPTURE ZONE (refer to Appendix 2.1)

*attach calculation sheets		RADIUS (m)
Arbitrary Fixed Radius		300
Calculated Fixed Radius	(1-year travel time)*	110
	(5-year travel time)*	247
	(10-year travel time)*	349

PARABOLIC CAPTURE ZONE (refer to Appendix 2.2)*

Downgradient distance 4 m

Width of capture zone 26 m

Is there a river, lake, pond, stream or other obvious surface water body within the 6-month time of travel boundary? ☒ yes *(identify on map)* ☐ no SPRING CK

Is there a stormwater and/or wastewater facility, treatment lagoon or holding pond located within the 6-month time of travel boundary? ☐ yes *(identify on map)* ☒ no

PART VII: SOURCE SURVEY (Refer to Step 3)

4 REGIONAL SOURCES OF RISK TO GROUND WATER

Please indicate if any of the following potential sources of contamination within the capture zone.

ACTIVITY	T.O.T. NOT SPECIFIED	1-YEAR	5-YEAR	10-YEAR	COMMENTS
Chemical Storage *(specify)*		✓			
Injection wells					
Abandoned wells					
Landfills, dumps, disposal areas					
Commercial/industrial sites					
Known hazardous materials clean-up site					
Household hazardous waste					
Population density > 2 houses per hectare		✓			
On-site sewage treatment					
Wastewater treatment facility					
Sites used for land application of waste					
Golf course					
Dairy or beef farms					
Poultry barns					
Hobby farms					
Fields: vegetables, hay, fruit *(specify)*			✓		
Mining operations					
Gravel pits					

** Mark and identify on map any of the potential sources listed above which are located within the capture zone boundary.

SEPTIC FIELD SETBACK 45 m or 150 ft.

GRADIENT TO SEPTIC FIELD ☐ upgrade ☐ downgrade ☒ same grade ____ % ____ %

DENSITY OF ON-SITE SEWAGE DISPOSAL SYSTEMS

COMMUNITY SYSTEM —

SYSTEM PER LOT 1 PER LOT (2-3/ha)

A-1 DRILLING Ltd.

"Specializing in Water Wells, Soil Sampling, Exploration"

RECEIVED
DEC 03 1993
LOWER MAINLAND REGION
FILE NO. ....

TELEPHONE
(604) 853-[redacted]
[redacted]
[redacted]
ABBOTSFORD, B.C.
V2S 4N7

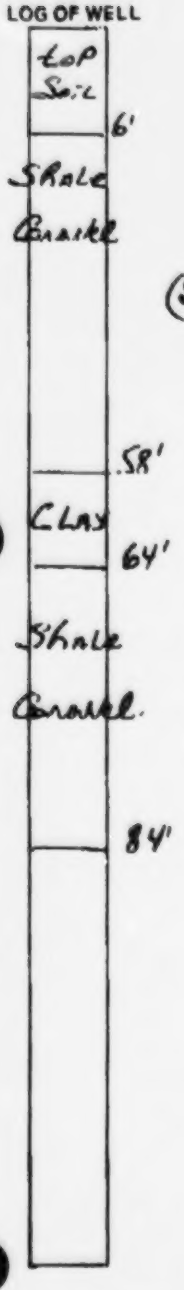
INVOICE 95-84

TO Charlie's Irrigation District

ADDRESS 9354 Pumphandle Highway Bypass

WELL DRILLED AT same

WELL COMPLETED June 1984 INVOICE DATE ....



	Machine Hours at .... per Hour	
64'×6"	Feet of Drilling at 25^{00} per Foot	1600^{00}
(Surface Casing) – 20'×8"	Feet of Drilling & Casing at 32^{00} per Foot	640^{00}
20'×6"	Feet of 6" overlap Casing at 6^{00} per Foot	120^{00}
	Feet of ...... Casing at .... per Foot	
	Feet of ...... Casing at .... per Foot	
1×6"	Drive Shoes at 86^{00} each	86^{00}
4'×6"	Feet of 80' Screen	440^{00}
	Installation of Screen	
	Pump Testing .... Hours at .... per Hour	
	Surging and Baling .... Hours at .... per Hour	
	Other Charges:	
	Moving on Site and Setting Up n/c	
	Blasting	
	Other Develope & Set Screen 3 hrs @ 80^{00}	240^{00}
	Room and Board	
	Travelling and Tolls	
	TOTAL INVOICE PRICE	3126^{00}

Notations Static H_2O Level 1'

Pumped well @ approx 100 Gallons Per Minute

INVOICE

- Account due on presentation of this Invoice. -
Interest at 1½% per Month (18% per Annum) on all accounts overdue 30 days.

Appendix 2: Hydrogeology of the Pumphandle Aquifer and Capture Zones for Pumphandle's Community Wells

Hydro-Logic Groundwater Consultants

Hydro-Logic Groundwater Consultants Ltd.
138 Alluvial Way
Delta, BC V8Z 4R6

December 15, 1998

Andrew Aiken
Aiken Waterworks Ltd.
RR 1
Pumphandle, BC
V8B 3G1

Dear Andrew Aiken:

As requested in your letter of November 16, 1998, our firm has compiled the groundwater information for the Pumphandle area and delineated the capture zones for the three community wells. We understand that your community planning team is currently in the process of developing a well protection plan for the three wells.

In this project, we have reviewed well records, surficial geology map (Armstrong, 1980), relevant groundwater reports (Carmichael, et al, 1995; Hydro-Logic, 1982; Kreye and Wei, 1994; and Mei, 1983) and air photos. We also obtained the aquifer classification map from the Ministry of Environment, Lands and Parks (1998), showing the lateral extent of the aquifer. This letter-report summarizes the hydrogeology and groundwater conditions in the Pumphandle area and presents the preliminary capture zones for the three community wells.

The Pumphandle Community Wells

The community of Pumphandle relies on three community wells operated by three separate water districts: Aiken Waterworks (Aiken's Well), Blackwater Waterworks (Blackwater Well), and Charlie's Improvement District (Charlie's Well). A summary of the three community wells is shown in Table 1.

Table 1: Summary of Pumphandle Community Wells

Well	Type	Depth (m)	Diameter (mm)	Rated Capacity (L/s)	Drinking Water Demand (L/s)	No. of users
Aiken	dug	2.4	915	5.10	5.26	500
Blackwater	drilled	30.5	200	22.73	1.05	100
Charlie	drilled	25.6	150	7.58	0.53	50

Aiken's Well is a very shallow well dug into a spring. It supplies the main subdivision in Pumphandle (165 homes – 5.26 L/s requirement) and has a rated capacity of 5.10 L/s. The water requirements exceed the maximum capacity of the shallow well, so it is likely that a new well will need to be drilled to meet future demands.

Blackwater Well supplies 35 homes (1.05 L/s requirements). However, the well is also used for irrigating the golf course and supplies the trailer campground, schools and hotels.

Charlie's Well supplies a subdivision of 15 homes (current requirements are 0.53 L/s). The well capacity has been rated at about fifteen times that amount (7.58 L/s), based on an initial pumping test conducted to prove up the water supply.

The Pumphandle Aquifer

Terraced sand and gravel deposits occupy the Pumphandle Valley and reach more than 60 m thick in the central part of the valley. The sand and gravel was deposited at the end of the last glacial period. The lower part of this permeable deposit is saturated and forms the principle aquifer – the Pumphandle Aquifer – that supplies groundwater to all the wells in the valley, including the three community wells. The aquifer rests above a layer of till of variable thickness which, in turn, rests on bedrock. The till and bedrock are less permeable and form aquitards.

Vulnerability of the Aquifer

The Ministry of Environment, Lands and Parks has designated the Pumphandle Aquifer as a moderately developed, moderately vulnerable, II B (12) aquifer. The aquifer is considered moderately vulnerable to contamination because it is unconfined, but the water table is fairly deep in most parts of the valley. Near the three community wells however, the water table is within a few metres of the surface and the aquifer is considered highly vulnerable at this location.

Groundwater Flow Direction

Mei (1983) estimated the contours of the water table from well records and showed that the water table slopes north towards the three community wells and then north-east towards the lake. It is assumed that groundwater flows the same way. The ambient hydraulic gradient (i) is about 0.1 at the side of the valley and decreases at the bottom of the valley near the three community wells. There is limited data to map the water table contour along the north-west edge of the valley so the groundwater flow direction there is not presently known.

The aquifer transmissivity near the community wells is about 3.60×10^{-3} m^2/s, based on pumping tests (Hydro-Logic, 1982). The slope of the water table suggests that recharge to the aquifer comes from precipitation falling on the aquifer and from mountain-front recharge. Groundwater in the aquifer ultimately discharges to the lake, the local creek and to pumping wells. The lake may also be a localized but significant source of recharge to the community wells during pumping.

Determining the Capture Zones for the Three Community Wells

The hydrogeological work done to date enabled the preliminary capture zones for the three community wells to be reasonably defined. Capture zones were defined using circular radius methods and analytical equations of groundwater flow. These methods are based on simple models of the aquifer and the following assumptions were made in applying the methods:

- the three community wells would pump at their maximum pumping rate,
- there is no interference between the wells, because of the low pumping rates relative to the transmissivity; the capture zones are therefore calculated separately for each well, and
- the effect of pumping of nearby private wells on the capture zone of the community wells is assumed to be insignificant.

The last assumption may be violated near large capacity irrigation wells. Significant pumping wells near the community wells will in effect result in larger capture zones. However, most of these wells are located up the valley from the community. In reality, the actual capture zones can not be known with certainty. However, the use of the maximum pumping rates will allow somewhat conservative capture zones to be defined.

Table 2 summarizes the capture zones defined for each well using the various methods. All three methods were applied to all three wells. For the Aiken well, the results from the fixed radius methods seem the most reasonable. Although a parabolic capture zone was calculated for the Aiken well, the transmissivity used for the calculation was estimated from wells elsewhere in the Pumphandle area. As such, there is a level of uncertainty associated with the capture zone determined using analytical equations. The calculated fixed radius method yields a ten-year radius of 310 m, which is about the size of an arbitrary fixed radius capture zone. However, Aiken's Well is located at the base of a terrace and it is obvious from the topography and water table contours that the flow comes directly from the higher ground to the south. The capture zone would therefore not be circular. Assuming the water table generally parallels the topography, the capture zone area for Aiken's Well would include the drainage area (about 80 ha) uphill to the edge of the aquifer boundary.

For the Blackwater Well, the parabolic capture zone determined using analytical equations seems most reasonable - it is physically based and the transmissivity value used in the calculation was based on the pump test data for that well (Hydro-Logic, 1982). Note that the parabolic capture zone is narrow and long, curving west and then south to the edge of the valley side. The narrow shape of the capture zone means that it is difficult to locate the capture zone without good control on the water table contours. In calculating the capture zone area for this well, the maximum pumping capacity was used to account for the heavy irrigation and high seasonal use.

The calculated fixed radius method was deemed most reasonable for Charlie's Well where the ambient water table is flat. The ten-year calculated fixed radius is 350 m (38 ha). The calculated fixed radius for the one-year and five-year time of travel was also calculated (Table 2). The maximum pumping capacity of the well was used to calculate the capture zone Charlie's Well, as this would account for any future growth and increased use of water for irrigation. This results in a rather larger capture zone than what it is now. Analytical equations are not accurate in this case because the water table is relatively flat and the ambient hydraulic gradient can not be determined with any accuracy. It is not clear if the ambient flow near Charlie's Well comes from the southeast or from the west-south-west. To determine this, nearby monitoring wells would be needed to provide groundwater level data to map the flow in more detail.

Table 2: Summary of Capture Zone Calculations

Well	Q	No. of users	T	b	i	AFR	CFR			Analytical Equations	
	(L/s)		(m^2/s)	(m)		(m)	r1yr (m)	r5yr (m)	r10yr (m)	Y (m)	X (m)
Aiken	5.10	500	0.0036	21	0.0917	**300**	99	221	312	8	2
Blackwater	22.73	100	0.0036	17	0.0368	300	232	518	733	**86**	**27**
Charlie	7.58	50	0.0036	25	0.0842	300	110	247	**349**	13	4

Bold text indicates the method chosen for each well.

Conclusions and Recommendations

- The three Pumphandle community wells, and other wells in the Pumphandle Valley, all tap a glaciofluvial sand and gravel deposit which forms the Pumphandle Aquifer; the Ministry of Environment, Lands and Parks has classified the Pumphandle Aquifer as a moderately developed, moderately vulnerable IIB (12) aquifer.
- The Pumphandle Aquifer is unconfined and is consider highly vulnerable to contamination from the land surface at the vicinity of the three community wells because the water table is shallow at this point.
- Groundwater recharge is likely from infiltration of precipitation falling in the up-valley area and from mountain-front recharge. Groundwater flow is generally towards Pumphandle Lake.
- Preliminary capture zone areas were determined for all three community wells using fixed radius and analytical methods; times of travel were also calculated for the capture zones where possible.
- Some uncertainty regarding the size and location of these capture zones exist because of limitations in the inherent assumptions of the delineation methods and because mapping of the water table surface was based on limited data.

- Although the actual location of the capture zones can not be known for certain, the use of maximum pumping rates for the wells will result in determining the maximum areas for the capture zones and provide a margin of safety.
- It is recommended that an observation well be established to monitor the water table fluctuation in the aquifer over the long term to understand the recharge-withdraw characteristics of the aquifer.
- When funding becomes available in the future, a numerical flow model should be developed for the Pumphandle Aquifer to more accurately define the capture zones for the community wells, to assess the potential impacts on the aquifer from proposed land use activities, and to assist in planning for the expansion of the water supply systems.

If you have any questions or need any clarification about the report, please don't hesitate to call me to discuss.

Sincerely,

Henrique Darcy, MS, P. Geo.
Hydrogeologist

References

Armstrong, J. E., 1980. *Surficial Geology of the Pumphandle Area, Map 1980-2*. Geological Survey of Canada.

Carmichael, V., M. Wei, and L. Ringham. 1995. *Fraser Valley Groundwater Monitoring Program Final Report.* Province of British Columbia. 104 pp. plus appendices and maps.

Ministry of Environment, Lands and Parks, 1998. *Aquifer Classification Map, Pumphandle BC.* Water Management Branch, Groundwater Section.

Hydro-Logic, 1982. *Pumping Test of Well 82-1, Blackwater Waterworks*. Unpublished report to Blackwater Waterworks, 15 pp.

Kreye, R. and M. Wei, 1994. *A Proposed Aquifer Classification System for Groundwater Management in British Columbia.* Unpublished report, Hydrology Branch, Water Management Division, Ministry of Environment, Lands and Parks. pp 68.

Mei, W., 1983. *Pumphandle Irrigation - ARDSA BC #437.* Unpublished memorandum, Groundwater Section, Water Management Division, Ministry of Environment, File 92G/2 #164.

M121

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APPENDIX 3: SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	1 YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
1st Priority A-1 hay field (15.4)	Ed Kotischyn	Blackwater Well				
2nd Priority A-2 hay field (34.1)	Janis Lobey		Charlie's Well			
2nd Priority A-3 hay field (114.4)	Jim Summer		Blackwater Well		Aiken's Well	
2nd Priority A-3 manure storage at poultry farm	Jim Summer		Blackwater Well			
2nd Priority A-3 abandoned well	Jim Summer		Blackwater Well			
1st Priority A-4 hay field (12.3)	Simon Lee	Blackwater Well				
1st Priority A-5 corn field (44.3)	Simon Lee		Blackwater Well		Aiken's Well	
2nd Priority A-6 corn field (46.7)	Manjit Dhaliwal					Blackwater Well

FOR PUMPHANDLE WELLS

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
NO_3 from fertilizers	Grows hay for feed; broadcasts fertilizers (15-15-10) three times a year from spring to fall	Fertilizers stored on pallets on cement floor in shed; shed is 30 m from pumphandle Creek	Septic system
NO_3 from fertilizers NO_3 from former corn field?	Grows hay for grazing; broadcasts fertilizers (15-15-10) once a year from spring to fall (60 Kg/ha)	Fertilizers stored on pallets on cement floor in shed; private well is 30 m uphill (south) of shed	Septic system
NO_3 from mixing fertilizer chemicals	Grows hay for feed; broadcasts fertilizers (15-15-10) three times a year from spring to fall (55-80 Kg/ha), also uses poultry manure	Fertilizers stored on pallets on cement floor in shed; well is 10 m from shed	Septic system
NO_3 from manure leachate	15,000 leghorns; follows Code of Practice, cleans out poultry barn every spring, uses some of the manure for hayfield, sells rest to other farmers in the area	Manure stockpiled in spring but covered with tarp	
A potential pathway for contaminants dumped down the well	Well is not used, the wellhead is covered with a 5-gal pail	N/A	
NO_3 from fertilizers	Grows hay for grazing; uses poultry manure once a year (2 truckloads/ha or 50 Kg N/ha)		
Pesticides, NO_3 from fertilizers	Grows Terrific and Supersweet Jubilee variety of corn; uses poultry manure from A-3 and elsewhere (1 truckload/ha or 25 Kg N/ha) and inorganic fertilizer (15-20-25), applied in spring before and after seeding (10 Kg N/ha); uses atrazine 500 for weed control (3.5 L/ha); fertilizer application not based soil testing	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets and pesticides in cabinets; the private well is located 200 m to the northeast	Septic System
Pesticides, NO_3 from fertilizers	Grows Supersweet Jubilee variety of corn; uses poultry manure from A-3 and elsewhere (1 truckload/ha) and inorganic fertilizer (15-20-25), applied in spring before and after seeding (20 kg N/ha); uses atrazine 500 for weed control (3.5 to 4.5 L/ha); fertilizer application not based on soil testing	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets on concrete floor and pesticides on shelves; the privates well are located 200 and 350 m to the northeast	Septic system

APPENDIX 3: SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	<1 YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
1st Priority A-1 hay field (15.4)	Ed Kotischyn	Blackwater Well				
2nd Priority A-2 hay field (34.1)	Janis Lobey		Charlie's Well			
2nd Priority A-3 hay field (114.4)	Jim Summer		Blackwater Well		Aiken's Well	
2nd Priority A-3 manure storage at poultry farm	Jim Summer		Blackwater Well			
2nd Priority A-3 abandoned well	Jim Summer		Blackwater Well			
1st Priority A-4 hay field (12.3)	Simon Lee	Blackwater Well				
1st Priority A-5 corn field (44.3)	Simon Lee		Blackwater Well		Aiken's Well	
2nd Priority A-6 corn field (46.7)	Manjit Dhaliwal					Blackwater Well

FOR PUMPHANDLE WELLS

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
NO_3 from fertilizers	Grows hay for feed; broadcasts fertilizers (15-15-10) three times a year from spring to fall	Fertilizers stored on pallets on cement floor in shed; shed is 30 m from pumphandle Creek	Septic system
NO_3 from fertilizers NO_3 from former corn field?	Grows hay for grazing; broadcasts fertilizers (15-15-10) once a year from spring to fall (60 Kg/ha)	Fertilizers stored on pallets on cement floor in shed; private well is 30 m uphill (south) of shed	Septic system
NO_3 from mixing fertilizer chemicals	Grows hay for feed; broadcasts fertilizers (15-15-10) three times a year from spring to fall (55-80 Kg/ha), also uses poultry manure	Fertilizers stored on pallets on cement floor in shed; well is 10 m from shed	Septic system
NO_3 from manure leachate	15,000 leghorns; follows Code of Practice, cleans out poultry barn every spring, uses some of the manure for hayfield, sells rest to other farmers in the area	Manure stockpiled in spring but covered with tarp	
A potential pathway for contaminants dumped down the well	Well is not used, the wellhead is covered with a 5-gal pail	N/A	
NO_3 from fertilizers	Grows hay for grazing; uses poultry manure once a year (2 truckloads/ha or 50 Kg N/ha)		
Pesticides, NO_3 from fertilizers	Grows Terrific and Supersweet Jubilee variety of corn; uses poultry manure from A-3 and elsewhere (1 truckload/ha or 25 Kg N/ha) and inorganic fertilizer (15-20-25), applied in spring before and after seeding (10 Kg N/ha); uses atrazine 500 for weed control (3.5 L/ha); fertilizer application not based soil testing	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets and pesticides in cabinets; the private well is located 200 m to the northeast	Septic System
Pesticides, NO_3 from fertilizers	Grows Supersweet Jubilee variety of corn; uses poultry manure from A-3 and elsewhere (1 truckload/ha) and inorganic fertilizer (15-20-25), applied in spring before and after seeding (20 kg N/ha); uses atrazine 500 for weed control (3.5 to 4.5 L/ha); fertilizer application not based on soil testing	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets on concrete floor and pesticides on shelves; the privates well are located 200 and 350 m to the northeast	Septic system

APPENDIX 3: SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	<1 YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
2nd Priority A-7 raspberry farm (40.7)	Manjit Dhaliwal					Blackwater Well
1st Priority C-1 gas station	Fred Kobeck			Charlie's Well	Aiken's Well	
2nd Priority C-2-hotel	Tim & Judy Sonoff					Charlie's Well
1st Priority C-3 golf course (46.4)	Jack Sonoff	Blackwater Well and Charlie's Well			Aiken's Well	
1st Priority C-4 dry cleaner	Linda and Andrew Winters			Charlie's Well	Aiken's Well	
2nd Priority I-1-gravel pit (19.3)	Joe Mielo				Aiken's Well	
1st Priority R-1 subdivision (7.2)	Jenny Lowden strata president				Aiken's Well	
1st Priority R-2 subdivision and campground (13.5)	Jocelyne Dufour campground owner and operator	Charlie's Well				

FOR PUMPHANDLE WELLS CONTINUED

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
Pesticides, NO_3 from fertilizers	Grows Chilliwack variety of raspberry; uses poultry manure as a soil conditioner/fertilizer (1 truckload/ha) and inorganic fertilizers (10-16-18), applied in the spring (30 Kg N/ha); uses minor amounts of simazine and diazinon for weed and pest control (amounts not known); fertilizer application not based on soil testing	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets and pesticides on shelves; the private well is located 100 m to the north	Septic system
Gasoline, pathogens & NO_3 from septic system, oils, chemicals	The tank is 20 years old and was tested for leaks in 1987 (none were found at the time); oils and solvents were stored in 45 gallon drums and taken to the regional landfill every week for disposal	Motor oil displayed in cashier area that is indoors and contained	Septic system is 35 m from Aiken's well
Pathogens & NO_3 from septic system	Uses cleaners and some solvents; uses garden fertilizers and lime for the lawn and Round-Up on the flower beds for weed control	Cleaners and solvents are stored in the janitorial room; wash water with cleaners are poured down the drains	Septic system is 40 m from Pumphandle Lake
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system	Uses fertilizers (20-20-10) and pesticides; light application of slow release fertilizer in late fall (amounts not reported); application of rapid release fertilizer in spring; application based on soil testing	Fertilizers and pesticides stored in physical plant shed, shed has a concrete floor; the shed is located 100 m south of Blackwater well and 150 m west of Charlie's well	Septic system
Solvents	Uses dry cleaning chemicals	Chemicals stored in locked cabinet	Septic system
None	Extract gravel and truck off-site; no processing	Motor oil stored in office	Septic system
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented	Some latex paints and motor oil stored in garden shed, along with the fertilizers and pesticides	Septic system density is high (28/ha)
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented	Latex and oil-based paints, thinners and motor oil stored in residential garages, along with the fertilizers and pesticides;	Septic system density is moderate (2-3/ha)

APPENDIX 3: SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	1 YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
2nd Priority A-7 raspberry farm (40.7)	Manjit Dhaliwal					**Blackwater Well**
1st Priority C-1 gas station	Fred Kobeck			**Charlie's Well**	Aiken's Well	
2nd Priority C-2-hotel	Tim & Judy Sonoff					**Charlie's Well**
1st Priority C-3 golf course (46.4)	Jack Sonoff	**Blackwater Well and Charlie's Well**			Aiken's Well	
1st Priority C-4 dry cleaner	Linda and Andrew Winters			**Charlie's Well**	Aiken's Well	
2nd Priority I-1-gravel pit (19.3)	Joe Mielo				Aiken's Well	
1st Priority R-1 subdivision (7.2)	Jenny Lowden strata president				Aiken's Well	
1st Priority R-2 subdivision and campground (13.5)	Jocelyne Dufour campground owner and operator	**Charlie's Well**				

FOR PUMPHANDLE WELLS CONTINUED

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
Pesticides, NO_3 from fertilizers	**Grows Chilliwack variety of raspberry; uses poultry manure as a soil conditioner/fertilizer (1 truckload/ha) and inorganic fertilizers (10-16-18), applied in the spring (30 Kg N/ha); uses minor amounts of simazine and diazinon for weed and pest control (amounts not known); fertilizer application not based on soil testing**	Fertilizers and pesticides are stored in the shed behind the house; fertilizers on pallets and pesticides on shelves; the private well is located 100 m to the north	**Septic system**
Gasoline, pathogens & NO_3 from septic system, oils, chemicals	**The tank is 20 years old and was tested for leaks in 1987 (none were found at the time); oils and solvents were stored in 45 gallon drums and taken to the regional landfill every week for disposal**	Motor oil displayed in cashier area that is indoors and contained	**Septic system is 35 m from Aiken's well**
Pathogens & NO_3 from septic system	**Uses cleaners and some solvents; uses garden fertilizers and lime for the lawn and Round-Up on the flower beds for weed control**	Cleaners and solvents are stored in the janitorial room; wash water with cleaners are poured down the drains	**Septic system is 40 m from Pumphandle Lake**
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system	**Uses fertilizers (20-20-10) and pesticides; light application of slow release fertilizer in late fall (amounts not reported); application of rapid release fertilizer in spring; application based on soil testing**	Fertilizers and pesticides stored in physical plant shed, shed has a concrete floor; the shed is located 100 m south of Blackwater well and 150 m west of Charlie's well	**Septic system**
Solvents	**Uses dry cleaning chemicals**	Chemicals stored in locked cabinet	**Septic system**
None	**Extract gravel and truck off-site; no processing**	Motor oil stored in office	**Septic system**
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	**Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented**	Some latex paints and motor oil stored in garden shed, along with the fertilizers and pesticides	**Septic system density is high (28/ha)**
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	**Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented**	Latex and oil-based paints, thinners and motor oil stored in residential garages, along with the fertilizers and pesticides;	**Septic system density is moderate (2-3/ha)**

APPENDIX 3: SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	1 YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
2nd Priority **R-3** **subdivision** **(4.9)**	Eric Kowski strata president					**Charlie's Well**
1st Priority **T-1** **main road**	Valley Regional District	**Blackwater Well**		**Charlie's Well**	Aiken's Well	

FOR PUMPHANDLE WELLS CONTINUED

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	**Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented**	Some latex paints and motor oil stored in garden shed, along with the fertilizers and pesticides	**Septic system density is moderate (3/ha)**
De-icing chemicals	**Uses de-icing chemicals during freezing conditions (up to 20 times a year between Nov-Feb)**	Chemicals stored in works yard 4 Km out of town	

APPENDIX 3: SOURCE ACTIVITIES AND POTENTIAL CONTAMINANTS

SOURCE ACTIVITY (AREA IN HA)	OWNER	<1 YR TIME OF TRAVEL	1-5 YR TIME OF TRAVEL	5-10 YR TIME OF TRAVEL	IN CAPTURE ZONE BUT NO TIME OF TRAVEL SPECIFIED	JUST OUTSIDE CAPTURE ZONE
2nd Priority R-3 subdivision (4.9)	Eric Kowski strata president					Charlie's Well
1st Priority T-1 main road	Valley Regional District	Blackwater Well		Charlie's Well	Aiken's Well	

FOR PUMPHANDLE WELLS CONTINUED

POTENTIAL CONTAMINANTS	LAND USE PRACTICE	STORAGE OF CHEMICALS	OTHER OBSERVATIONS
Pesticides, NO_3 from fertilizers, pathogens & NO_3 from septic system, degreasers	Fertilizers and pesticides (commercial products such as Round-Up) used in various amounts; amounts unknown and undocumented	Some latex paints and motor oil stored in garden shed, along with the fertilizers and pesticides	Septic system density is moderate (3/ha)
De-icing chemicals	Uses de-icing chemicals during freezing conditions (up to 20 times a year between Nov-Feb)	Chemicals stored in works yard 4 Km out of town	

APPENDIX 4

SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
1 A-1 to 4 hay fields (does not address historic corn field at A2)	**Encourage growers to optimize fertilizer use & implement Best Management Practices (BMPs)**	Specify BMPs for fertilizer & irrigation	**Record fertilizer & water use; measure crop yield**	Farmer on CPT[13] is already implementing BMP at A-4	**Consult MAF[14] & AC[15] on BMP**	Farmer on CPT and purveyor to talk to growers at A-1, 2, & 3; implement BMPs by next year	**Pass**
2a. A-5, 6 corn fields	**Encourage growers to optimize fertilizer use & implement BMP to reduce nitrate loading**	See 1	**See 1**	Landowner at A-5 on CPT & is already implementing BMP	**Consult MAF's environmental guidelines on field corn production**	Farmer on CPT and purveyor to talk to grower at A-6; implement BMP within 2 years for A-6	**Pass**
2b.	**Encourage growers to reduce pesticide use with IPM plan**	Identify alternative pest control methods, develop IPM & implement	**Reduced pesticide use; regular inspections**	Technical assistance available from consultants	**Consult MAF & hire pest management consultants**	Farmer on CPT and purveyor to talk to grower at A-6; implement IPM by next year for A-5 & within 2 years for A-6	**Pass**
3a. A-7 raspberry field	**Encourage growers to optimize fertilizer use & implement BMP**	See 1	**See 1**	Landowner at A-7 was cooperative during inventory survey in Step 3	**Consult MAF's environmental guidelines on berry production**	Farmer on CPT and purveyor to talk to grower at A-7; implement BMP within 2 years	**Pass**
3b.	**Encourage growers to reduce pesticide use by implementing IPM plan**	See 2b	**See 2b**	See 2b	**See 2b**	As above	**Pass**
4a. A-3 poultry barn	**Handle & dispose of manure in accordance with MELP's Code of Practice**	Landowner implements Code of Practice	**Periodic inspections**	MELP[16] to enforce regulation	**Code of Practice is regulation**	Already being done; MELP to begin inspections by next year	**Pass**
4b.	**Grower to dispose of carcasses to compost facility in accordance with MELP's Code of Practice**	Temporarily hold carcasses in freezer container & regularly dispose at compost facility	**Records at compost facility; periodic inspection**	Nominal cost for disposal	**Done elsewhere**	Implement next year	**Pass**
5a. C-3 private golf course	**Encourage owner to minimize herbicide & pesticide use through IPM plan**	Develop IPM for herbicide & pesticide use & implement	**Reduced quantity of herbicide & pesticide use; regular inspections**	Greens can be maintained using eco-friendly maintenance techniques, training of grounds keepers required	**Consult DFO[17] & EC[18] guidelines & industry association forBMP (e.g. Canadian Golf Superintendent Association)**	Farmer on CPT and purveyor to talk to the golf course owner at C-3; implement within 2 years	**Pass**
5b.	**Encourage owner to minimize fertilizer use & implement BMP**	See 1	**Reduced fertilizer & water use; periodic inspections**	As above	**As above**	As above	**Pass**

APPENDIX 4

SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES continued

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
5c.	Encourage owner to maintain septic system	Annual maintenance of septic system by owner	Septic system maintenance records	Reasonable cost (<$500)	Routinely done elsewhere	Implement by next year	Pass
5d.	Pass by-law to require regular maintenance of septic system	Create by-law to require owners in capture zone to maintain septic system annually	Maintenance records	<$200 for household system; <$500 for community system	As above (example draft by-law available from other municipalities)	Make proposal to Regional District planner; pass by-law within 2 years	Pass
6a. R-1-3 trailer park & subdivision	Include 2-page newsletter in water bill about wise use of garden fertilizers & pesticides, disposal of household hazardous waste, & water conservation	CPT produce one newsletter & mail to clients	One newsletter produced & distributed	Pumphandle Valley Conservation Society and the purveyors designs newsletter & Regional District pays for copying; advice on content from MELP & Regional District	Done in other municipalities	Implement immediately & send out in next water & pad rental bills; repeat on annual basis with up-dates & articles	Pass
6b.	Organize hazardous waste collection annually (paints, solvents/flammable liquid/pesticides)	Collect household paints & solvents; include information in two-page newsletter	Ship household wastes to depots once a year	Paint depot in Chilliwack; solvent depot to be established by 1998; call depot to set-up drop-off	Call B.C. Recycling Hotline or Paint Care Association (604-482-8686) for more information	CPT to organize collection annually	Pass
6c.	Encourage owners to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
6d.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5d	See 5c	See 5d	Pass
7a. hotel	Encourage owner to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
7b.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5d	See 5c	See 5d	Pass
8a. abandoned well	Grout well in accordance with MELP's draft Code of Practice	Hire driller to grout & cap well	Well capped & grouted; driller's records	Cost ~$1K	Common industry practice	EHO to talk to owner of A-3; obtain well construction record; hire driller by Fall	Pass
9a. I-1 gravel pit	Erect signs, "*No Dumping in Gravel Pit*" along the fence	Produce & erect signs (by owner)	Signs produced & erected by pit staff	$50/sign	Pit staff to do this on slow days	Regional Engineer to talk to pit owner/operator at I-1 & MEM's[19] District Manager; have sign erected by Fall	Pass

APPENDIX 4

SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
1 A-1 to 4 hay fields (does not address historic corn field at A2)	Encourage growers to optimize fertilizer use & implement Best Management Practices (BMPs)	Specify BMPs for fertilizer & irrigation	Record fertilizer & water use; measure crop yield	Farmer on CPT[13] is already implementing BMP at A-4	Consult MAF[14] & AC[15] on BMP	Farmer on CPT and purveyor to talk to growers at A-1, 2, & 3; implement BMPs by next year	Pass
2a. A-5, 6 corn fields	Encourage growers to optimize fertilizer use & implement BMP to reduce nitrate loading	See 1	See 1	Landowner at A-5 on CPT & is already implementing BMP	Consult MAF's environmental guidelines on field corn production	Farmer on CPT and purveyor to talk to grower at A-6; implement BMP within 2 years for A-6	Pass
2b.	Encourage growers to reduce pesticide use with IPM plan	Identify alternative pest control methods, develop IPM & implement	Reduced pesticide use; regular inspections	Technical assistance available from consultants	Consult MAF & hire pest management consultants	Farmer on CPT and purveyor to talk to grower at A-6; implement IPM by next year for A-5 & within 2 years for A-6	Pass
3a. A-7 raspberry field	Encourage growers to optimize fertilizer use & implement BMP	See 1	See 1	Landowner at A-7 was cooperative during inventory survey in Step 3	Consult MAF's environmental guidelines on berry production	Farmer on CPT and purveyor to talk to grower at A-7; implement BMP within 2 years	Pass
3b.	Encourage growers to reduce pesticide use by implementing IPM plan	See 2b	See 2b	See 2b	See 2b	As above	Pass
4a. A-3 poultry barn	Handle & dispose of manure in accordance with MELP's Code of Practice	Landowner implements Code of Practice	Periodic inspections	MELP[16] to enforce regulation	Code of Practice is regulation	Already being done; MELP to begin inspections by next year	Pass
4b.	Grower to dispose of carcasses to compost facility in accordance with MELP's Code of Practice	Temporarily hold carcasses in freezer container & regularly dispose at compost facility	Records at compost facility; periodic inspection	Nominal cost for disposal	Done elsewhere	Implement next year	Pass
5a. C-3 private golf course	Encourage owner to minimize herbicide & pesticide use through IPM plan	Develop IPM for herbicide & pesticide use & implement	Reduced quantity of herbicide & pesticide use; regular inspections	Greens can be maintained using eco-friendly maintenance techniques, training of grounds keepers required	Consult DFO[17] & EC[18] guidelines & industry association forBMP (e.g. Canadian Golf Superintendent Association)	Farmer on CPT and purveyor to talk to the golf course owner at C-3; implement within 2 years	Pass
5b.	Encourage owner to minimize fertilizer use & implement BMP	See 1	Reduced fertilizer & water use; periodic inspections	As above	As above	As above	Pass

SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
5c.	Encourage owner to maintain septic system	Annual maintenance of septic system by owner	Septic system maintenance records	Reasonable cost (<$500)	Routinely done elsewhere	Implement by next year	Pass
5d.	Pass by-law to require regular maintenance of septic system	Create by-law to require owners in capture zone to maintain septic system annually	Maintenance records	<$200 for household system; <$500 for community system	As above (example draft by-law available from other municipalities)	Make proposal to Regional District planner; pass by-law within 2 years	Pass
6a. R-1-3 trailer park & subdivision	Include 2-page newsletter in water bill about wise use of garden fertilizers & pesticides,disposal of household hazardous waste,& water conservation	CPT produce one newsletter & mail to clients	One newsletter produced & distributed	Pumphandle Valley Conservation Society and the purveyors designs newsletter & Regional District pays for copying; advice on content from MELP & Regional District	Done in other municipalities	Implement immediately & send out in next water & pad rental bills; repeat on annual basis with up-dates & articles	Pass
6b.	Organize hazardous waste collection annually (paints, solvents/flammable liquid/pesticides)	Collect household paints & solvents; include information in two-page newsletter	Ship household wastes to depots once a year	Paint depot in Chilliwack; solvent depot to be established by 1998; call depot to set-up drop-off	Call B.C. Recycling Hotline or Paint Care Association (604-482-8686) for more information	CPT to organize collection annually	Pass
6c.	Encourage owners to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
6d.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5d	See 5c	See 5d	Pass
7a. hotel	Encourage owner to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
7b.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5d	See 5c	See 5d	Pass
8a. abandoned well	Grout well in accordance with MELP's draft Code of Practice	Hire driller to grout & cap well	Well capped & grouted; driller's records	Cost ~$1K	Common industry practice	EHO to talk to owner of A-3; obtain well construction record; hire driller by Fall	Pass
9a. I-1 gravel pit	Erect signs, "*No Dumping in Gravel Pit*" along the fence	Produce & erect signs (by owner)	Signs produced & erected by pit staff	$50/sign	Pit staff to do this on slow days	Regional Engineer to talk to pit owner/operator at I-1 & MEM's[19] District Manager; have sign erected by Fall	Pass

SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES continued

Activity	**Management Option**	Specific	**Measurable**	Achievable	**Realistic**	Time-bound	**Pass-Fail S*M*A*R*T test**
9b.	**Educate workers on handling, storing & disposing of petroleum products & spill response**	Hang poster in pit office, staff take training & post emergency phone list in office	**Poster hung, course taken & phone list posted**	Order poster from MELP, have manager develop safety program and deliver to staff, & compile emergency phone list with CPT	**Staff well aware of groundwater protection efforts**	As above	**Pass**
10a. gas station	**Test tanks for leaks & keep records on gas bought/sold**	Annually test; volume bought/ sold reviewed by operator	**Annual report to CPT**	Operator already tracking volume of gas in tank	**Common practice**	Continue; EHO to discuss with owner about testing tank annually until new tank is installed	**Pass**
10b.	**Encourage owner to replace existing tanks with newer double-lined tanks & install monitors to detect any leaks**	Install new tanks	**New tank installed**	Company considering as part of renovation for next year	**Estimated cost for 50,000 L tank is $5-10,000**	EHO to discuss with owner to consider	**Pass**
10c.	**Encourage owner to maintain septic system**	See 5c	**See 5c**	See 5c	**See 5c**	Implement by next year	**Pass**
10d.	**Pass by-law to require regular maintenance of septic system**	See 5d	**See 5d**	See 5c	**See 5d**	See 5d	**Pass**
11a. dry cleaner[20]	**Encourage owner to adopt CCME[21] Code of Practice for operation**	Follow CCME guidelines	**Periodic inspection**	Guidelines developed with industry	**Guidelines available**	EHO to talk to owner; adopt Code of Practice in 1 year	**Pass**
11b.	**Encourage owner to recycle perc[22]**	Volume of perc traceable	**Volume perc recycled**	Recycled by distributor	**Being done in Ontario**	Set up recycling by next year	**Pass**
11c.	**Encourage owner to take spill response course**	Take course in Vancouver	**Course certificate**	$200-400 for course	**Owner write off as business expense**	Take course in Fall	**Pass**
11d.	**Encourage owner to join industry association (e.g. B.C. Fabricare Association) & implement BMP**	Join association	**Membership list**	$190 for annual membership (includes membership in International Fabricare Association)	**Owner write off as business expense**	Join within 1 year	**Pass**
11e.	**Pass by-law to restrict the quantity of perc in the capture zone**	Enact by-law	**By-law passed**	Regional District is interested	**Present dry cleaner in close proximity to Allen's and Charlie's Wells**	CPT to make proposal to Regional District planner; have by-law within 2 years	**Pass**
12a. T-1 main road	**Erect signs, "*Entering Groundwater Protection Area of Pumphandle, B.C. Please do not pollute. For more information, call 555-1234* on main road near trailer park (R3) & hay field (A1)**	Produce & erect 2 signs	**Signs erected; calls for more information received**	$300/sign	**2 signs produced by local volunteer students & erected by Regional District**	Talk to school & Regional District about project; implement by next year	**Pass**

SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES

Activity	**Management Option**	Specific	**Measurable**	Achievable	**Realistic**	Time-bound	**Pass-Fail S*M*A*R*T test**
12b.	**Develop roadside display & put up at parking lot in front of gas station-dry cleaner**	One display with map showing the aquifer & the well protection plan	**One display put up; calls for more information received**	As part of student project for road signs	**~$1K**	Erect display in May next year – in time for tourist season	**Pass**
12c.	**Encourage Regional District to develop eco-friendly road maintenance program, including less use of herbicides & salt on road R/W**	Identify eco-friendly alternatives for road maintenance & implement	**Reduced use of chemicals**	Practices elsewhere	**Apply to 2 km of main road**	Implement in 18 months	**Pass**

[13] CPT = Community planning team, [14] MAF = Ministry of Agriculture and Food, [15] AC= Agriculture Canada, [16] MELP = Ministry of Environment, Lands and Parks, [17] DFO = Department of Fisheries and Oceans, [18] EC = Environment Canada [19] MEM= Ministry of Energy and Mines, [20] Standards being developed by Environment Canada, [21] CCME = Canadian Council of the Ministers of the Environment, [22] perc = perchloroethylene, a solvent used in the dry cleaning industry

SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	Management Option	Specific	Measurable	Achievable	Realistic	Time-bound	Pass-Fail S*M*A*R*T test
9b.	Educate workers on handling, storing & disposing of petroleum products & spill response	Hang poster in pit office, staff take training & post emergency phone list in office	Poster hung, course taken & phone list posted	Order poster from MELP, have manager develop safety program and deliver to staff, & compile emergency phone list with CPT	Staff well aware of groundwater protection efforts	As above	Pass
10a. gas station	Test tanks for leaks & keep records on gas bought/sold	Annually test; volume bought/sold reviewed by operator	Annual report to CPT	Operator already tracking volume of gas in tank	Common practice	Continue; EHO to discuss with owner about testing tank annually until new tank is installed	Pass
10b.	Encourage owner to replace existing tanks with newer double-lined tanks & install monitors to detect any leaks	Install new tanks	New tank installed	Company considering as part of renovation for next year	Estimated cost for 50,000 L tank is $5-10,000	EHO to discuss with owner to consider	Pass
10c.	Encourage owner to maintain septic system	See 5c	See 5c	See 5c	See 5c	Implement by next year	Pass
10d.	Pass by-law to require regular maintenance of septic system	See 5d	See 5d	See 5c	See 5d	See 5d	Pass
11a. dry cleaner[20]	Encourage owner to adopt CCME[21] Code of Practice for operation	Follow CCME guidelines	Periodic inspection	Guidelines developed with industry	Guidelines available	EHO to talk to owner; adopt Code of Practice in 1 year	Pass
11b.	Encourage owner to recycle perc[22]	Volume of perc traceable	Volume perc recycled	Recycled by distributor	Being done in Ontario	Set up recycling by next year	Pass
11c.	Encourage owner to take spill response course	Take course in Vancouver	Course certificate	$200-400 for course	Owner write off as business expense	Take course in Fall	Pass
11d.	Encourage owner to join industry association (e.g. B.C. Fabricare Association) & implement BMP	Join association	Membership list	$190 for annual membership (includes membership in International Fabricare Association)	Owner write off as business expense	Join within 1 year	Pass
11e.	Pass by-law to restrict the quantity of perc in the capture zone	Enact by-law	By-law passed	Regional District is interested	Present dry cleaner in close proximity to Aiken's and Charlie's Wells	CPT to make proposal to Regional District planner; have by-law within 2 years	Pass
12a. T-1 main road	Erect signs, "*Entering Groundwater Protection Area of Pumphandle, B.C. Please do not pollute. For more information, call 555-1234* on main road near trailer park (R3) & hay field (A1)	Produce & erect 2 signs	Signs erected; calls for more information received	$300/sign	2 signs produced by local volunteer students & erected by Regional District	Talk to school & Regional District about project; implement by next year	Pass

SELECTED MANAGEMENT OPTIONS FOR POTENTIAL CONTAMINANT SOURCES CONTINUED

Activity	**Management Option**	Specific	**Measurable**	Achievable	**Realistic**	Time-bound	**Pass-Fail S*M*A*R*T test**
12b.	**Develop roadside display & put up at parking lot in front of gas station-dry cleaner**	One display with map showing the aquifer & the well protection plan	**One display put up; calls for more information received**	As part of student project for road signs	**~$1K**	Erect display in May next year – in time for tourist season	**Pass**
12c.	**Encourage Regional District to develop eco-friendly road maintenance program, including less use of herbicides & salt on road R/W**	Identify eco-friendly alternatives for road maintenance & implement	**Reduced use of chemicals**	Practices elsewhere	**Apply to 2 km of main road**	Implement in 18 months	**Pass**

[13] CPT = Community planning team, [14] MAF = Ministry of Agriculture and Food, [15] AC= Agriculture Canada, [16] MELP = Ministry of Environment, Lands and Parks, [17] DFO = Department of Fisheries and Oceans, [18] EC = Environment Canada [19] MEM= Ministry of Energy and Mines, [20] Standards being developed by Environment Canada, [21] CCME = Canadian Council of the Ministers of the Environment, [22] perc = perchloroethylene, a solvent used in the dry cleaning industry

APPENDIX 5

PROPOSED SCHEDULE FOR IMPLEMENTING MANAGEMENT OPTIONS

Land Use Activity	1999 Summer	Fall	Winter	2000 Spring	Summer	Fall	Winter	2001 Spring
Hay fields (A-1 to A-4)	Talk to farmers about adopting BMPs	→	→	Implement BMPs	→	→	→	→
Corn fields (A-5, 6)	Talk to farmers about adopting BMPs & IPMs	→	→	→	→	→	→	Implement BMPs & IPMs
Raspberry field (A-7)	Talk to farmers about adopting BMPs & IPMs	→	→	→	→	→	→	Implement BMPs & IPMs
Poultry barn (A3)	Farmers to implement Code of Practice	Implement BMP for manure disposal		MELP begins inspection Implement BMP for carcass disposal	→	→	→	→
Golf course (C-3)	Talk to owner about maintaining septic system & implement BMPs & IPMs	→	→	Maintain septic system	→	→	→	Implement BMPs & IPMs →
Campground & subdivision (R-1 to R-3)	Develop & send out 2-page newsletter			Maintain septic system	→	→	→	→
Hotel (C-2)				Maintain septic system	→	→	→	→
Abandoned well (A-3)		Grout off well						
Gravel pit (I-1)		Erect signs & train staff in proper waste storage & disposal						
Gas station	Talk to owner about testing tanks & installing new tanks Take course in spill response	→ Take course in spill response	→	Maintain septic system	→	→	→	→
Dry cleaner	Talk to owner about taking spill response course	Take course in spill response	→	→	→	Join industry association Adopt Code of Practice	→	→
Main road (T-1)	Identify eco-friendly methods of road maintenance	→	→	Erect signs on main road	Implement road maintenance program	→	→	→
Septic System Maintenance By-Law	Draft by-law for consultation	Consultation	→	→	Present by-law to elected officials	→	→	→

APPENDIX 5

PROPOSED SCHEDULE FOR IMPLEMENTING MANAGEMENT OPTIONS CONTINUED

Land Use Activity	1999 Summer	Fall	Winter	2000 Spring	Summer	Fall	Winter	2001 Spring
Restricted Storage of Hazardous Chemicals By-Law	→		Draft by-law for consultation	→			Present by-law to elected officials	
Community Hazardous Waste Collection	Develop Household Hazardous Wastes program	→		Hold first Household Hazardous Wastes collection				
Public education	Develop & send out 2-page newsletter							

APPENDIX 5

PROPOSED SCHEDULE FOR IMPLEMENTING MANAGEMENT OPTIONS

Land Use Activity	1999 Summer	Fall	Winter	2000 Spring	Summer	Fall	Winter	2001 Spring
Hay fields (A-1 to A-4)	Talk to farmers about adopting BMPs	→	→	Implement BMPs	→	→	→	→
Corn fields (A-5, 6)	Talk to farmers about adopting BMPs & IPMs	→	→	→	→	→	→	Implement BMPs & IPMs
Raspberry field (A-7)	Talk to farmers about adopting BMPs & IPMs	→	→	→	→	→	→	Implement BMPs & IPMs
Poultry barn (A3)	Farmers to implement Code of Practice	Implement BMP for manure disposal		MELP begins inspection Implement BMP for carcass disposal	→	→	→	→
Golf course (C-3)	Talk to owner about maintaining septic system & implement BMPs & IPMs	→	→	Maintain septic system	→	→	→	Implement BMPs & IPMs →
Campground & subdivision (R-1 to R-3)	Develop & send out 2-page newsletter			Maintain septic system	→	→	→	→
Hotel (C-2)				Maintain septic system	→	→	→	→
Abandoned well (A-3)		Grout off well						
Gravel pit (I-1)		Erect signs & train staff in proper waste storage & disposal						
Gas station	Talk to owner about testing tanks & installing new tanks Take course in spill response	→ Take course in spill response	→	Maintain septic system	→	→	→	→
Dry cleaner	Talk to owner about taking spill response course	Take course in spill response	→	→	→	Join industry association Adopt Code of Practice	→	→
Main road (T-1)	Identify eco-friendly methods of road maintenance	→	→	Erect signs on main road	Implement road maintenance program	→	→	→
Septic System Maintenance By-Law	Draft by-law for consultation	Consultation	→	→	Present by-law to elected officials	→	→	→

APPENDIX 5

PROPOSED SCHEDULE FOR IMPLEMENTING MANAGEMENT OPTIONS continued

Land Use Activity	1999 Summer	Fall	Winter	2000 Spring	Summer	Fall	Winter	2001 Spring
Restricted Storage of Hazardous Chemicals By-Law	→	→	Draft by-law for consultation	→	→	→	Present by-law to elected officials	
Community Hazardous Waste Collection	Develop Household Hazardous Wastes program	→	→	Hold first Household Hazardous Wastes collection				
Public education	Develop & send out 2-page newsletter							

APPENDIX 6

CONTINGENCY RESPONSES TO POTENTIAL CONTAMINANTS

Most Likely Event	Trigger	Contaminant Source/ Activity	Contingency Activity	Contact
Nitrate contamination of Aiken's, Blackwater or Charlie's Wells	Water quality monitoring Report of bad practices	Hay fields (A-1, 2, & 3) Corn fields (A-5 & 6) Golf course (C-3) Subdivision (R-1), subdivision and campground (R-2)	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source	Environmental Health Officer (EHO) Water purveyor of affected well
Pesticide contamination	Water quality monitoring Report of bad practices	Golf course (C-3)	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source	EHO Water purveyor of affected well Ministry of Environment, Lands and Parks (MELP)
Gasoline contamination	Complaint of odour in the water Water quality monitoring Spill reported	Gas station	Contact MELP Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source Contain spill	EHO Water purveyor of affected well MELP
Dry cleaning liquid contamination	Water quality monitoring Spill reported	Dry cleaner	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source Contain spill	EHO Water purveyor of affected well MELP
Chemical spill or road salt contamination	Water quality monitoring Spill reported	Main road	Clean up spill Issue public advisory Provide alternate drinking water Expand monitoring to determine source Contain spill	MELP Fire department EHO Water purveyor of affected well
Contamination by household wastes	Water quality monitoring	Subdivision (R-1 and/or R-3) Subdivision and campground (R-2)	Issue public advisory Chlorinate affected well if bacteria present Provide alternate drinking water Expand monitoring	EHO Water purveyor of affected well

APPENDIX 6

CONTINGENCY RESPONSES TO POTENTIAL CONTAMINANTS

Most Likely Event	Trigger	Contaminant Source/ Activity	Contingency Activity	Contact
Nitrate contamination of Aiken's, Blackwater or Charlie's Wells	Water quality monitoring Report of bad practices	**Hay fields (A-1, 2, & 3)** **Corn fields (A-5 & 6)** **Golf course (C-3)** **Subdivision (R-1), subdivision and campground (R-2)**	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source	**Environmental Health Officer (EHO)** **Water purveyor of affected well**
Pesticide contamination	Water quality monitoring Report of bad practices	**Golf course (C-3)**	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source	**EHO** **Water purveyor of affected well** **Ministry of Environment, Lands and Parks (MELP)**
Gasoline contamination	Complaint of odour in the water Water quality monitoring Spill reported	**Gas station**	Contact MELP Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source Contain spill	**EHO** **Water purveyor of affected well** **MELP**
Dry cleaning liquid contamination	Water quality monitoring Spill reported	**Dry cleaner**	Issue public advisory Provide alternate source of drinking water Expand monitoring to determine source Contain spill	**EHO** **Water purveyor of affected well** **MELP**
Chemical spill or road salt contamination	Water quality monitoring Spill reported	**Main road**	Clean up spill Issue public advisory Provide alternate drinking water Expand monitoring to determine source Contain spill	**MELP** **Fire department** **EHO** **Water purveyor of affected well**
Contamination by household wastes	Water quality monitoring	**Subdivision (R-1 and/or R-3)** **Subdivision and campground (R-2)**	Issue public advisory Chlorinate affected well if bacteria present Provide alternate drinking water Expand monitoring	**EHO** **Water purveyor of affected well**

Appendix 7: Pumphandle Water Quality Sampling Form

CHEMISTRY REQUISITION FORM NUMBER: ______________________
WELL IDENTIFIER NUMBER: ______________________

well use: domestic ☐ community ☐

well type: unconsolidated ☐ bedrock ☐

dug ☐ sand point ☐ drilled ☐

well depth: ____________ m / ft
static water level: ____________ m / ft from:
____

SAMPLING METHOD

collect from tap: inside ☐ outside ☐

describe location of tap:
____

duration: ____________ minutes

FIELD MEASUREMENTS / OBSERVATIONS

Time (mins.)	Water Temp. (°C)	Specific Conductance (μS/cm)	pH	NO_3-N (mg/L)	Odour	Colour	Notes

comments: ______________________

Complete and attach this form to the laboratory chemistry requisition form and keep one copy for your records.

Appendix 8: Sampling Protocol for Domestic Wells for Physical and Inorganic Chemical Analyses

Note: Prior to sampling a domestic well in the field it is necessary that you have detailed information on the specific well you are sampling! You should have a copy of the well record and well location with you. If the well is regularly monitored and is tagged with a unique *Well Identifier Number*, confirm the number against your records. Establish with the well/property owner that the record you have is correct and represents the well you are about to sample. If no well record is available, obtain as much information on the well/location from the well/property owner as possible. A water quality sampling form to record information is appended. The well/property owner may also have a copy of the driller's log.

The following is a list of equipment you may require:

- coolers (large and small)
- one-litre bottles and 250-ml bottles (pre-labelled)
- sample requisition forms (filled out)
- conductivity meter, nitrate test kit and pocket pH meter
- gallon bucket and stop watch
- filtering equipment and filters

Following is the step-by-step procedure for sampling a domestic well:

1. Introduce yourself, show identification and explain to the well/property owner the reason you are requesting a water sample. Whenever possible, contact the owner to set up a time to come and sample.

2. Determine whether the inside or outside cold water tap is the preferred sampling point. Consult with the well/property owner and find out if the water is treated (e.g. does the water system have a water softener installed?) If so, obtain a sample before water goes through any treatment. Choose a tap as close as practical to the well. Describe sampling location on the sampling form (see step 7). If sampling is part of on-going monitoring, sample at the same location every time.

3. Turn the tap on full or near full flow for a minimum of three to five minutes if possible. Explain to the well/property owner that this is necessary because you need to obtain a water sample that represents as close as possible the true groundwater chemistry. Ask well/property owner if s/he has used the water recently (e.g. laundry, dishes, garden watering). If so, it may not be necessary to run the water for the full five minutes. Caution: For low yielding wells, it may not be possible to purge up to five minutes. Please consult with owner and well record. This is a judgement call by you as the sampler.

4. Monitor the water temperature (+/- 0.5° C), specific conductance (+/- 10 µS/cm), pH (+/- 0.1), and NO_3 - N (+/- 2.0 - 3.0 mg/L) during purging to check that water quality is

stable before collecting the sample. Also record any physical characteristics of the water (colour, odour etc.). If the sample point is from an outside tap direct the water into a container (e.g. bucket) if available, for plants, garden, trees etc. (don't needlessly waste the well/property owner's water!). Since you need to purge up to five minutes, pick a sample location where water discharge will not be a problem.

Bottle requirements for physical and inorganic analysis are as follows:

Physical and Inorganic sample bottle requirements		
Volume	**Preservative/Filtration**	**Parameters Analyzed for**
1 L	none (no acid wash either)/none	pH, conductivity, alkalinity, bicarbonate
250 ml	none/filtered	fluoride, chloride, sulfate, NO_2, NO_3 ammonia, dissolved metals and hardness
250 ml	nitric acid/none	total metals

Unfiltered sample: (One 1-litre bottle and one 250 ml bottle). Rinse 1 litre bottle out three times with purging water and turn water flow down to a gentle (pencil thick) stream, then collect sample. Fill one 1-litre plastic bottle. Make sure the inside of the bottle and cap are not touched. Tighten cap securely and ensure that threads are not cross threaded. Fill one 250 ml plastic bottle (Do not rinse bottle before filling). Fill to the top of the bottle allowing no head space, again ensure that the inside of the cap and bottle are not touched. Tighten cap securely and ensure that threads are not cross threaded.

Filtered sample: (One 250 ml bottle). Fill a one-litre bottle. A portion of this water is then filtered through a 45 µm disposable filter using the peristaltic pump and one 250 ml bottle filled, again allowing no head space (Do not rinse bottle before filling). Tighten cap securely and ensure that threads are not cross threaded. The peristaltic pump has the option of using 115 V and powered by the generator or clipped to the battery terminals. As another option, filter the sample manually using a filter and a filter stand. Always rinse out the filtering and pump equipment with deionized water after every sample.

5. Inform well/property owner that you will send them a copy of the chemical analysis with an explanation of the analysis when you receive results.

6. Label samples and place in cooler with ice pack. Make sure samples are placed upright or near upright in cooler. Make sure samples have proper identification (i.e. name of well, address of well, EMS number on all samples, date and time of sampling, preservation

codes; F = filtered, NF = non-filtered, P = preserved, NP = not preserved on all bottles and name and phone number of sampler). Place packing material (newspaper/foam chips) around samples to ensure they do not move in cooler during transport to laboratory. Complete chemistry requisition form (attached) and place in clear plastic zip-lock bag and place in cooler. Make sure you have the correct client code on the chemistry requisition form. Make sure you have removed the "sampler copy" of the requisition form for your records. Tape destination label on cooler lid and make sure the cooler has return address. Tape cooler shut.

7. Record all pertinent information on the *Pumphandle Water Quality Sampling* form (sample source, duration tap run prior to sample collection etc.) for future reference and attach to "sampler copy" of sample requisition form. Record the time when and place where samples or sample batches were forwarded to the laboratory. If a duplicate external QA/QC sample is collected remember to note this duplicate sample in your records.

8. Transport samples to nearest courier office as soon as possible and fill out the necessary courier form. Whenever possible, samples should be received by laboratory with a 24 hour period. Notify the laboratory that the samples have been shipped and provide any special instructions.

9. Do not sample on Fridays because the samples will sit in the laboratory on the weekend before they are analyzed.

Helpful Hints:

The secret to successful sampling is being organized !

- Have a map of the area with you showing the wells to be sampled.
- Label bottles and coolers and fill out chemistry requisition forms prior to sampling.
- Have a variety of cooler sizes with you.
- Have lots of packing material with you (e.g. newspaper, foam chips).
- Carry lots of large zip-lock bags with you.
- Carry the correct amount of bottles and coolers.
- Have all necessary information on wells to be sampled.
- Telephone well/property owners and inform them when you expect to be in the area to sample their well.
- Have a dedicated refrigerator to store samples if necessary and re-freeze ice packs.

- Try to have water sampling completed and shipped to the laboratory by Thursday morning at the latest.
- Carry stapler, paper clips, large felt pens, nylon tape, courier forms.
- Carry standard conductivity meter, thermometer, nitrate test kit and pocket pH meter with you.

Water samples are sent via courier to the address below:

CHEMTEST LABORATORY
2975 JUTLAND HIGHWAY
NORTH VANCOUVER, B.C.
V7H 1V2

Any questions from the lab?
Call Megan Lei, Head of Inorganic Chemistry Section at (604) 924-2521 or
fax at (604) 924-2555.

Good Luck !

Appendix 9: List of Parameters for Comprehensive Laboratory Analysis

Physical Parameters

Alkalinity Phen. 8.3
Alkalinity Total 4.5
Hardness Dissolved & Total
pH
Residue Filterable - 0.45 µm
Specific Conductance

Major Ions

Ammonium-Nitrogen
Bicarbonate
Calcium Dissolved & Total
Chloride Dissolved
Fluoride Dissolved
Magnesium Dissolved & Total
Nitrate and Nitrite-Nitrogen
Nitrate-Nitrogen
Nitrite-Nitrogen
Potassium Dissolved & Total
Sodium Dissolved & Total
Sulfate

Metals

Aluminum Dissolved & Total
Arsenic (low level) Dissolved & Total
Boron Dissolved & Total
Barium Dissolved & Total
Beryllium Dissolved & Total
Bismuth Dissolved & Total
Cadmium Dissolved & Total
Cobalt Dissolved & Total
Chromium Dissolved & Total
Copper Dissolved & Total
Iron Dissolved & Total
Manganese Dissolved & Total
Molybdenum Dissolved & Total
Nickel Dissolved & Total
Phosphorus Dissolved & Total
Sulfur Dissolved & Total
Silicon Dissolved & Total
Strontium Dissolved & Total
Tellerium Dissolved & Total
Thallium Dissolved & Total
Tin Dissolved & Total
Vanadium Dissolved & Total
Zinc Dissolved & Total
Zirconium Dissolved & Total

Volatile Organic Compounds

Halogenated Volatiles

Bromodichloromethane
Bromoform
Bromomethane
Carbon Tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethylvinyl ether
Chloroform
Chloromethane
Dibromochloromethane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,1-Dichloroethane
1,2-Dichloroethane
trans-1,2-Dichloroethylene
1,1-Dichloroethylene
1,2-Dichloropropane
1,3-Dichloropropane
cis-1,3-Dichloropropylene
trans-1,3-Dichloropropylene
Ethylene Dibromide
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Trichlorofluoromethane
1,2,2-Trichloropropane
Vinyl Chloride

Non-Halogenated Volatiles

Benzene
Ethylbenzene
Styrene
Toluene
meta- & para-Xylene
ortho-Xylene

Pesticides

Organochlorines

Alachlor
Alpha Chlordane
Captan
Chlorothalonil
Dicofol
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Gamma Chlordane
Heptachlor
Heptachlor Epoxide
Naled
op-DDE
op-DDT
pp-DDE
pp-DDT

Neutrals and Acids

EPTC
Butylate
Chlorpropham
Chlorpyrifos
Diazinon
Dimethoate
Fensulfothion
Iprodione
Malathion
Metalaxyl
Metachlor
Metribuzin
Napropamide
Oxyfluorfen
Parathion

Acids

2,3,4,6-Tetrachlorophenol
2,4,6-Trichlorophenol
2,4-D
2,4-Dichlorophenol
Dicamba
Dinoseb
MCPA
Pentachlorophenol

Neutrals

Aldicarb Sulfoxide
Atrazine
Azinophos-methyl
Carbaryl
Carbofuran
Linuron
Methomyl
Oxamyl
Simazine

List of parameters may change over time; consult your local health authority.